INSTRUCTIONS

FOR THE USE OF

ESTERLINE-ANGUS MODEL A. W.

GRAPHIC INSTRUMENTS

THE ESTERLINE-ANGUS COMPANY, INC.
INDIANAPOLIS, INDIANA, U. S. A.

SERIAL NUMBER

5-24-61

THE ESTERLINE-ANGUS COMPANY, INC.

P. O. BOX 596 • INDIANAPOLIS 6, INDIANA, U. S. A.

RECORDER DATA SHEET for Model AW AC VOLTMETER

Sold to Boeing Airplane Co., Seattle, Wash.

Pur. Order No. 2-260652-9914 . MO No. . SO No. M 2101 . Date 5-5-61

For use by Same

CASE Portable . For panel. Lamp

Other Case Features

MEASURING ELEMENT AC Voltmeter . NP No. 8912 . ME No. 340-A

Scale 0-150 Volts AC . Sc. No. V-15-150 . **CHART No.** 1316-C

Calibrated for Use With . Damping No. 3.0 A

Calibration or Rating: Wire 2 . Phase Single . Cycles 60 . Pressure

Voltage 0-150/300/600 Volts (Max. Volts)

Current (Max. Amps)

Watts Gen. Drive Shaft RPM

Millivolts at amp. ( ) at 30° C. at Shunt End of Leads.

Mult. Box Attached . No. 8850 . Volts 150/300/600 Volts . Mult. NP No.

E Mult. Box . No. . Volts . Mult. NP No.

Range 150 V. Total Ohms: A 1134 B . Mult. Ohms: A 920 B . MV at Meter: A

Range 300 V. Total Ohms: A 2308 B . Mult. Ohms: A 2094 B . MV at Meter: B

Range 600 V. Total Ohms: A 4619 B . Mult. Ohms: A 4405 B . Comp. Ohms: A

Range Total Ohms: A B . Mult. Ohms: A B . Comp. Ohms: B

Range . TC.

Armature Ohms: A 214 B . Parallel Cir. Ohms . Meter Ohms . FS Grams Torque STD.

E LEADS—Current: No. , ft. long, No. wire. Potential: 2 No. 8935 , 5 ft. long, No. 14 wire.

ID No. D1803 . Connection Diagrams D-940 . Lead ohms . Lead MV

Other Measuring Element Features

CHART DRIVE: Type No. 4, Minute Feed Synchronous

Feeds: In. per Hr. 3/4-1½-3-6-12 . In. per Min. 3/4-1½-3-6-12 . In. per Sec.

FS No. 90-M (Mod.G) . Internal Motor: Volts 120 . Cycles 60

Int. Trip Coil: No. . Volts . Cycles . Ohms . Series Ohms

External Motor: FS No. . Volts . Cycles . No. . Rheo.

E Other Chart Drive Features Furnish one 8935-C Lead

ATTACHMENTS

Right Hand Chron. Pen: No. . Volts . Cycles . Ohms . Series Ohms

Left Hand Chron. Pen: No. . Volts . Cycles . Ohms . Series Ohms

DIELECTRIC TESTS (AC Volts): Meter Element 5000 . Internal Motor 1500 . Ext. Motor

Lamp Circuit . Chronograph Pens . Trip Coils . Aux. Transf.

AUXILIARY APPARATUS FURNISHED BY ESTERLINE-ANGUS

E
- POT. TRANSF: . Mfr. . Model . Volts: Pri. . Sec. . Cycles
- CUR. TRANSF: . Mfr. . Model . Amperes: Pri. . Sec. . Cycles
- Phase shifting Network: . No. . Volts . Cycles . Volts . Cycles
- Tachometer Generator: Model . Internal Gears . Armature RPM at Full Scale
- SHUNTS: . Type . Rated amperes . MV . Amp. at Rated MV

OFFICIAL RECORDS STATION
FILE COPY
FACILITIES FEB - - 1962

DS by JEH . DS check by . Calib. by

Inspections: 1st . Final Press . Date MAY 15 1961

Meter card entry

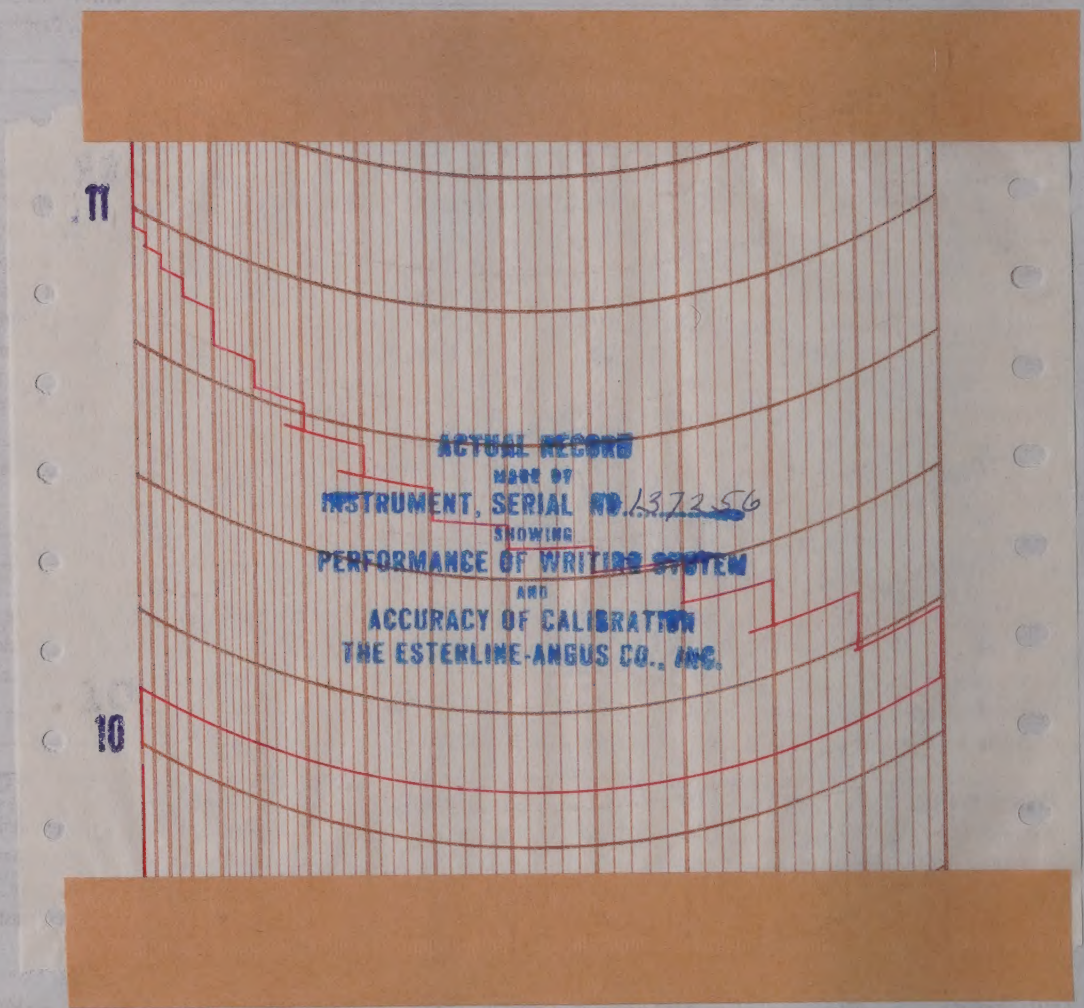
FORM 281 9-57

SERIAL No. ~~137256~~ AW

Mention this number in correspondence.

#14

P. ACVM 150/300/600 V. 90M 120-60


11
ACTUAL RECORD
MADE BY
INSTRUMENT, SERIAL NO. 137256
SHOWING
PERFORMANCE OF WRITING SYSTEM
AND
ACCURACY OF CALIBRATION
THE ESTERLINE-ANGUS CO., INC.
10

GENERAL INSTRUCTIONS FOR OPERATION AND MAINTENANCE OF ESTERLINE-ANGUS MODEL AW RECORDING INSTRUMENTS

Esterline-Angus recorders are simple to service and to operate. However, no attempt to put an instrument into operation should be made until the instruction book and the appropriate connection diagrams have been studied. Faulty connections or improper servicing may result in unsatisfactory operation or damage to vital parts of the instrument.

Directions for threading the chart and for operating the drive at various chart speeds are given in Section 20 of this Instruction Book. Also clearly described in Section 20 are the correct procedures for filling the inkwell and priming the pen. If the recorder is properly connected and regularly serviced, it can be expected to give continuous trouble-free service.

UNPACKING

Esterline-Angus instruments are carefully packed; carriers are responsible for damage in transit. If the packing case shows damage, make a notation to that effect on your express receipt or freight bill. If it is found that the shipment has been damaged, notify the carrier at once.

Included with each shipment is a packing list showing every item in the shipment. Check off each item as the goods are unpacked, and if any item appears to be missing, go through the packing material carefully before throwing it away. The missing articles may have been overlooked when the packing material was removed.

Each instrument is carefully inspected at the Esterline-Angus factory and then sealed before shipment. New instruments are shipped complete with one record chart and a box of accessories containing one 2 oz. bottle of red ink, one inkwell filler, one pen filler, and a pen point cleaner. Two charts and two accessory boxes are furnished with twin instruments.

INSTALLING

The instrument should be mounted where it will not be subjected to vibration or extremes of temperature. If excessive steam, smoke, moisture, dust or corrosive fumes are present, a protective cabinet should be built around the instrument. Front switchboard, wall, and flush instruments should be mounted level in a clean, light place. It has been found that these instruments can be easily read and serviced if installed with the bottom of the case about four feet above the floor. Mounting dimensions (already furnished by the factory) should be followed when holes are drilled in preparation for mounting the recorder on a panel.

Front or flush-switchboard instruments can be mounted either on slate or steel panels. However, front-switchboard DC instruments calibrated for customary steel-panel mounting will read slightly high when installed on an insulating panel. Recorders specified for insulating panels will be properly calibrated for this type of installation.

Series resistances for front switchboard and wall-type recorders, when required, are housed in separate boxes and marked with the recorder serial number. Resistance boxes for portable and flush recorders are attached directly to the instrument case. All separate boxes must be mounted vertically. Never put a resistance box in a small closed compartment or obstruct the flow of air through it.

Do not locate instruments close to bus bars or cables carrying large currents. This is especially important for DC wattmeters, whose readings may be affected by strong stray magnetic fields.

Shunts should be mounted with at least three feet of unbroken bus bar extending from both ends. Switchboard type shunts must be mounted with the blades vertical to permit free circulation of air. Never crowd a shunt into the bus structure between other shunts or install it above another shunt.

The cases of portable, front switchboard, and wall-type instruments have latches that can be sealed with standard meter seals or locked with a small padlock. On all flush cases, the door is fitted with a lever handle having a built-in lock. Two keys are furnished with each instrument and these keys fit any flush-case lock.

CONNECTING

Do not connect the instrument without first referring to the wiring diagrams in this Instruction Book. A wrong connection may cause the instrument to read incorrectly or may cause permanent damage. All terminals are marked with an identifying letter, number or voltage. Positive instantaneous polarity on an AC instrument is indicated by the prime mark (′). This mark appears both on the instrument terminals and on the connection diagrams.

If an AC recording instrument is connected into a circuit with another recorder or indicating instrument, care must be taken to connect the current circuits in series. For example, if a recording wattmeter and an ammeter are connected into the secondary circuit of the same current transformer, the ammeter must be connected in series with the current circuit of the wattmeter so that the entire transformer secondary current will pass through each of the instruments.

Whenever it is known that a recorder is to be connected into a circuit with other instruments, Esterline-Angus furnishes with it a diagram showing this connection. If this diagram is not available to the installer, he must be sure to connect the current circuits of AC instruments in series and not in parallel. If an AC ammeter is connected in parallel with the current circuit of an AC wattmeter, both instruments will have large errors.

Current leads are furnished for recorders used with external shunts, and are marked with the instrument serial number. Recorders with current leads are calibrated for the correct measuring-circuit voltage drop AT THE SHUNT END OF THE LEADS, and only these leads should be used in the current circuits. Other connections should be made with No. 14 wire or larger.

All portable instruments, with the exception of recording milliammeters and microammeters are furnished with a set of leads. These leads have taper plugs on the instrument end and open-spade terminals on the other end. Keep the plugs and terminals clean to insure good contact.

All recorder terminals for plug connections are threaded inside so that the instrument can be fitted with binding posts. These posts can be obtained from the Esterline-Angus Company. Orders should include the serial number of the instrument on which the posts will be used. BINDING POSTS SHOULD NOT BE USED ON ANY RECORDER OPERATED FROM SHUNTS. Only the calibrated leads furnished with the recorder should be used for this purpose.

SETTING ZERO POSITION

The following applies to all Esterline-Angus recorders except pressure, vacuum, position and motion recorders. Zero adjustment on these instruments is covered in the section of the instruction book pertaining to these types of recorders.

Zero setting should be periodically checked. The instrument will not record correctly if the pen does not rest on the zero line of the chart when no signal is applied to the recorder input terminals. If adjustment is necessary, it can easily be made with the adjusting lever located above the nameplate on the bottom of the case.

Before attempting this adjustment, make sure that the pen element is properly gauged for length, full of ink and correctly balanced. (See "Care of the Inking System" on the following page.) Zero setting is made by tapping the pen table with a finger while the zero adjusting lever is moved until the pen rests exactly on the zero line.

INSPECTING THE RECORD

Any length of chart can be pulled from the reroll for inspection of the record. Pull the chart straight out from the reroll. The reroll has a lock system, and a sudden release of tension on the unrolled portion of the chart will lock the reroll, removing tension from the chart and allowing it to be examined at leisure. To rewind the chart, first pull it forward slightly from the reroll to release the lock, and then let it wind slowly back onto the reroll.

REMOVING THE RECORD CHART

To remove the rerolled chart, grasp the chart with the left hand and push down the reroll latch on the right side. Pull the chart reroll forward out of the instrument.

To remove the chart from the reroll, pull the plug out of the right end of the reroll tube by grasping the edge of the right-hand disk. The chart can then be pulled off the tube by holding the disk on the gear end. If the chart sticks on the tube, twist the tube in a counter-clockwise direction (as seen from the gear end) as it is being withdrawn from the chart.

The chart is then ready for inspection or filing. An Esterline-Angus Chart Inspector is a useful device for routine examination of

record charts, and its purchase is suggested if a number of charts are to be studied.

FEEDING USED CHART OUT OF BOTTOM OF CASE

On all instrument cases, except the flush (which requires a special notch in the door) provision is made for feeding the used chart out of the case through a slot in the bottom. To feed through this slot instead of rerolling, remove the rubber strip at the lower edge of the case cover. The end of the chart hanging out of the case should be weighted. A paper clamp is sufficiently heavy for this purpose. Do not pull or jerk on the end of the chart, as this may throw it out of time.

CARE OF THE INKING SYSTEM

Use only Esterline-Angus recorder ink. It is made especially to satisfy the exacting requirements encountered in recording instruments. Keep the bottle tightly capped to minimize evaporation and to prevent dirt from getting into the ink. EA ink begins to thicken at low temperatures and heat must be provided in the instrument if the temperature stays below 20 Fahrenheit.

The inking system should be inspected once a week. Fresh ink should be added to the inkwell when necessary and any dirt, lint or dried ink on the pen point should be removed. Each time the inkwell is filled, ink should be drawn through the pen element by means of the pen filler. This flushes any thickened ink from the element. Once a month the inkwell and pen element should be emptied, washed, and refilled with fresh ink. On those recorders operating at high temperatures or those equipped with high-speed external motor attachments, this process should be carried out every week or two depending on ambient temperature and humidity.

To clean the inkwell, pry off the cover and wash the parts in water. The pen element is best cleaned by forcing water through it with a pen filler. Intermittent writing, failure of the pen to write on sudden swings, a dark purplish color of the record line instead of the normal bright red, or a tendency of the ink to spread in the paper and produce a broad, fuzzy line, all are indications that the ink in the inkwell has thickened and oxidized, and that the inking system should be serviced more often.

Instruments are shipped with the pen elements properly balanced WHEN FULL OF INK and the balance adjustment should not be changed unless necessary. The pen balance should be such that when the chart is tapped lightly with one finger, the pen will bounce up and down on the chart. Too heavy a pen pressure on the chart will cause the pen to drag toward the center of the chart or will noticeably reduce the speed of response of the pen. Accordingly, if maximum speed of response is desired, the pen pressure must be no greater than is necessary to produce satisfactory inking.

The replaceable metal pen point should be a push fit into the end of the pen element tube. Therefore, extra pen points have a sizing wire furnished with them for use when the new point fits loosely into the pen element tube. To use this wire insert it into the pen element tube and squeeze the tube about 1/16 inch from its end with narrow flat-nosed pliers. Remove the sizing wire and insert the tip of the long end of the pen point into the tube. Place a drop of lacquer or nail polish on the body of the pen point and then push and twist it into the tube until the distance from the knife-edge pivot to the pen point is 4-3/8". The lacquer or nail polish will seal the point into the tube. The point should be positioned so that it rests perpendicular to the chart when the pen element is installed in the recorder.

Should a pen require re-balancing, it can be accomplished through adjustment of the balance weights on the pen element nearer to or farther away from the knife-edge pivot. The weights will stay locked in place when screwed tightly against each other.

Handle the pen element carefully; a bent element will cause incorrect readings. The writing tip of the pen point must be exactly 4-3/8 inches from the knife edge. The arc line, drawn by the pen, is approximately 1/8 inch in front of the curved edge of the metal chart feeder which extends over the pen table. It is advisable to have an extra Pen element for use in the event that the one in the recorder is inadvertently damaged. See "Supplies and Spare Parts" on the following page.

In servicing, take every precaution against spilling ink on the recorder. If ink is accidentally spilled, it should be removed immediately with a cloth or damp paper towel. If ink is spilled on clothing, the spots should be washed as soon as possible, preferably with warm water and Lava soap. Persistent washing will usually remove such spots.

CAUTION: *Always remove the pen and inkwell before taking the chart drive out of the instrument or before subjecting the instrument to any handling which may spill the ink.*

TECHNICAL INFORMATION

Each Esterline-Angus recording instrument is accompanied by a technical data sheet which gives information pertaining to the instrument. This data sheet is a part of the Instruction Book and should be kept for reference. Part of this information will also be found on the nameplate inside of the case, at the bottom. On the back of the data sheet will be found an original record made by the instrument as it was checked at the factory. In correspondence about this instrument, always mention the serial number. This number is stamped on the nameplate inside the meter case and on the chart drive nameplate. Both locations are clearly shown on page 1 of the Illustrated Section which follows.

SUPPLIES AND SPARE PARTS

Although the Esterline-Angus factory is prepared to ship charts and ink within two or three days after the order is received, the user should forecast his need for these essential items so that his instrument need never be idle for want of supplies. Keep on hand at all times enough charts and ink to operate each recorder for at least one month. By purchasing in larger quantities, worthwhile savings can be made on these items.

INK---Esterline-Angus ink is supplied in two colors, red and green. Both colors are put up in two-ounce and one-pint bottles. Red ink is standard and will be supplied unless otherwise specified.

SPARE PARTS- -When ordering parts, always give the instrument serial number as well as individual part numbers. Refer to the measuring element and chart drive assembly prints in this book for the part numbers.

CHARTS- -Record charts should be ordered by number. This number will be found on the right-hand edge of the used chart. A list of all charts with standard ranges is included in the Chart Catalog Section of this book.

GUARANTEE

Esterline-Angus instruments are guaranteed to be free from defects due to faulty materials or workmanship. Any instrument proving defective within two years from date of shipment will be repaired or replaced free of charge when returned to our factory, shipping charges prepaid, provided the instrument has not been tampered with or misused. We do not assume responsibility for repairs made outside our factory.

PACKING FOR SHIPMENT

If the instrument is to be returned to the factory for repairs, send for shipping instructions and at the same time state clearly the reason for return. If time does not permit this normal handling, the following procedure may be used: Wash out the inkwell and the pen element. Replace the emptied inkwell but do not replace the pen element in its saddle. Instead, tie it across the top of the scaleplate. Expense can be saved on many repair jobs if the precaution to REMOVE ALL LIQUID INK from the instrument is observed. Remove studs from switchboard instruments. Protect the glass front with a small board, wrap and seal the instrument in heavy paper to prevent excelsior from sifting into the mechanism. It is preferable that portable, switchboard and wall instruments be returned with the front covers in place. This protects the chart drive and keeps packing particles out of the instrument.

ALL LEADS for DC wattmeters or ammeters, also any SEPARATE MULTIPLIER BOXES MUST BE RETURNED to the factory when the recorder is to be REPAIRED OR RECALIBRATED. Return the entire set of leads furnished with portable recorders. If the instrument being returned is a speed recorder, return the tachometer generator and any indicators used with it. If only the chart drive is in need of repair, it should be removed from the recorder, eliminating the necessity of shipping the entire instrument.

Use a strong packing box, large enough to permit at least eight inches of dry excelsior on all sides of the instrument. Ship by prepaid express and mark:

"ELECTRICAL INSTRUMENT,
HANDLE CAREFULLY."

THE ESTERLINE-ANGUS COMPANY

INDIANAPOLIS 6, INDIANA
U.S.A.

IS10, 10M
SEPTEMBER, 1960

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GENERAL INSTRUCTIONS
FOR THE OPERATION AND CARE OF
ESTERLINE-ANGUS CHART DRIVES

The step-by-step procedures pictured here show how to chart and ink all Esterline-Angus Model AW recorders. This may be more easily accomplished on recorders in portable, front switchboard and wall cases if the case cover is removed. To do this, open the latch and swing the cover open 3-5 inches. Then slide the lower end of the cover in toward the recorder case and lift it off the hinge hooks.

For specific information on the operation and care of your particular chart drive, refer to the instruction sheet immediately following this one.

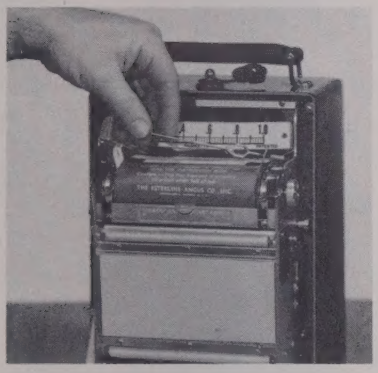

Fig. 1 – Carefully remove the pen element from the tie-up card. Be sure the pen tube is not bent in removal.

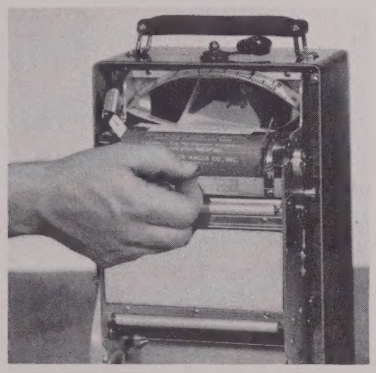

Fig. 2 – Raise the scaleplate, remove the tie-up card and cut the string holding the change gears in place.

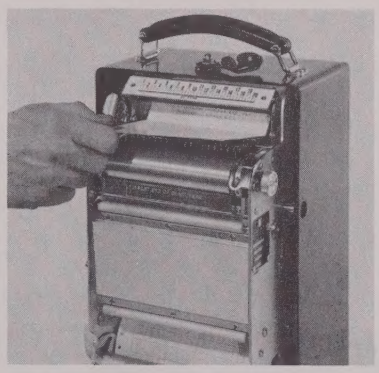

Fig. 3 – Operation Recorder Only – Cut the string holding the pen elements and scaleplate. Tilt scaleplate and remove the tie-up card.

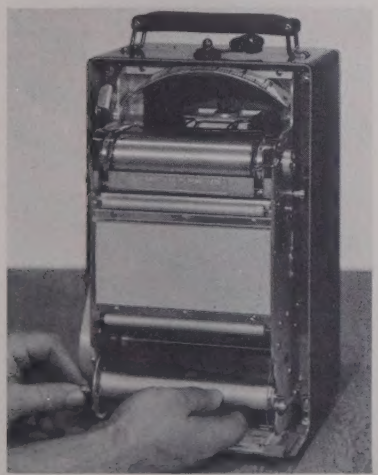

Fig. 4 – Press down the reroll latch, either left or right, and remove the reroll roller.

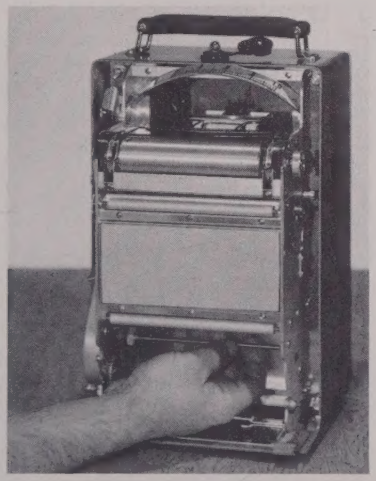

Fig. 5 – Grasp the supply roll arbor, lift up and pull forward to remove.

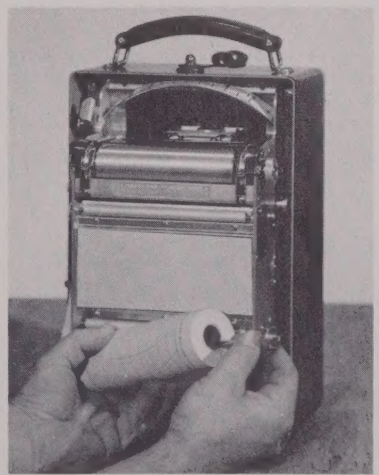

Fig. 6 – Insert the arbor in the chart core, and center it, with elongated chart perforations to the right.

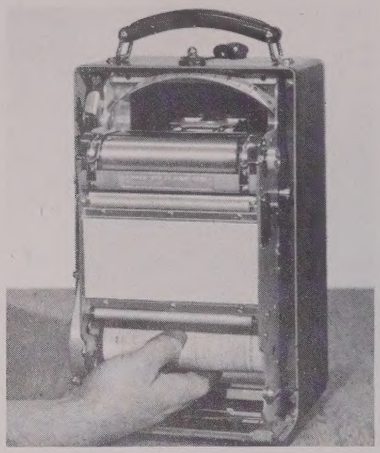

Fig. 7 – Push new chart in place. Supply arbor must snap in its slots and chart roll turn freely.

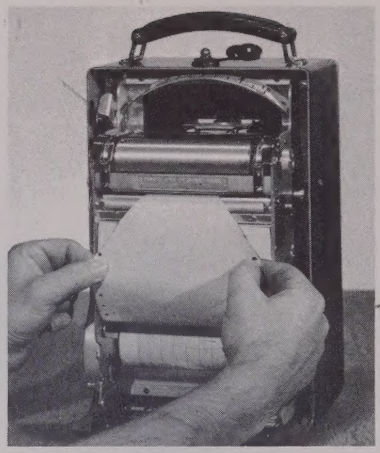

Fig. 8 – Tear or cut end of chart to a "V" shape. Feed chart into slot marked "Insert End of Chart Here".

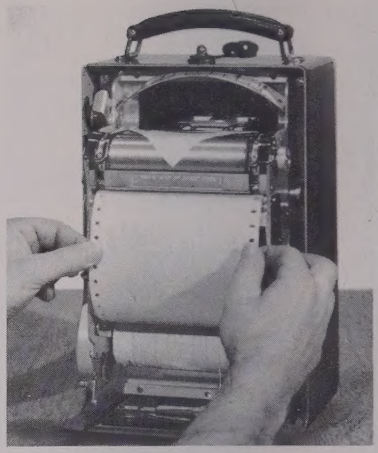

Fig. 9 – Push chart into the slot until the point hangs over the drive roll.

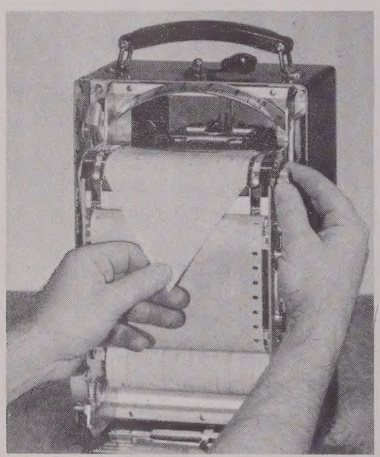

Fig. 10 – Turn the knurled set knob on drive roll ahead, and pull the chart carefully until the drive roll pins engage the chart perforations.

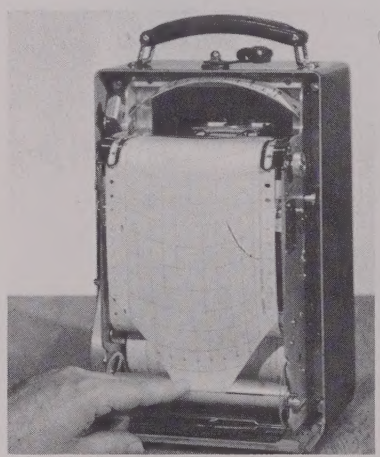

Fig. 11 – Snap the reroll roller in place, gear end to the left. Insert "V" end of chart into slot in the roller and crease. Turn reroll roller back about 1/4 turn to release brake. It may be necessary at this point to start the drive so that the reroll will take up the chart.

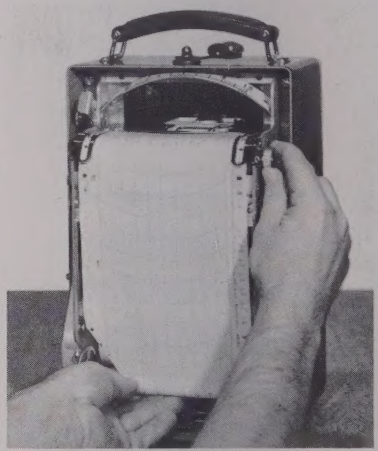

Fig. 12 – Turn the set knob forward with the right hand while allowing the reroll to turn forward in the left hand. Be sure that the chart rolls smoothly on the reroll.

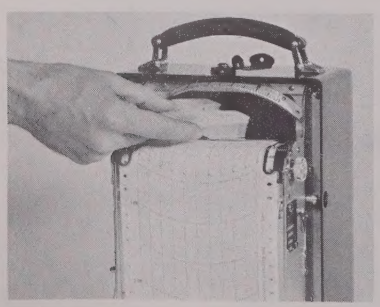

Fig. 13 – Grasp the handles of the inkwell and lift up and forward to remove it from the meter.

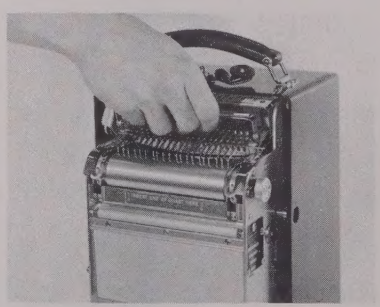

Fig. 14 – Operation Recorder Only – Grasp operation recorder inkwell bail handle. Lift up and over the pen lifter wire, removing both inkwell and pens.

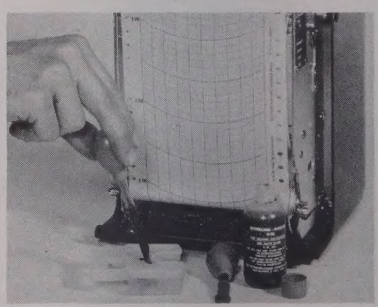

Fig. 15 – With the inkwell filler, transfer E-A ink from the bottle to the inkwell. Fill the inkwell a little over half full.

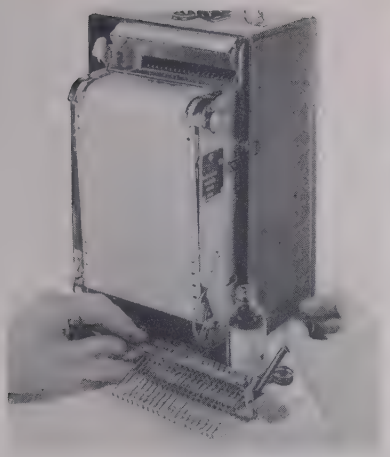

Fig. 16 – Operation Recorder Only – Use the inkwell filler to transfer E-A ink from the bottle to the inkwell. Fill the inkwell a little over half full.

Fig. 17 – Replace the inkwell by pushing it under the spring holder prongs and allow it to slide forward until sitting level and clamped in place.

Fig. 18 – Operation Recorder Only – Replace inkwell and pen elements. Be sure that pen tails engage lever arms and that inkwell seats firmly. Do not tip inkwell during replacement.

Fig. 19 – Place the pen element in the pen fork. (Left handed is easiest.) Pen must balance freely on its knife edge. The point will remain off the chart until the pen is filled with ink.

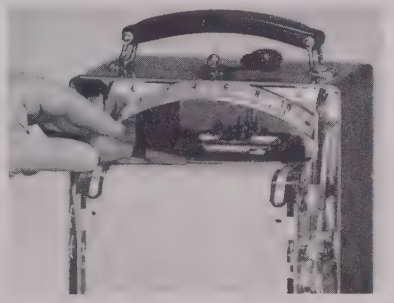

Fig. 20 – Compress bulb and insert pen point in the hole in the tip of the pen filler. Release the bulb slowly until ink appears in the glass tube of the pen filler. Wash the pen filler with water after servicing the recorder.

Fig. 21 – Operation Recorder Only – Repeat procedure of Fig. 20 with each pen. A pair of tweezers will facilitate lifting each pen and inserting it in the hole in the pen filler.

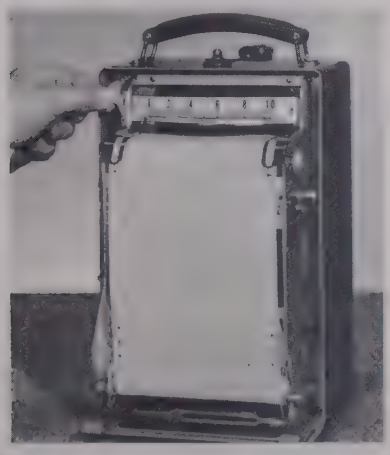

Fig. 22 – Check to see that proper change gears are in place to match the time markings on the chart. The table on page 4 shows the proper gears to use for each standard chart speed.

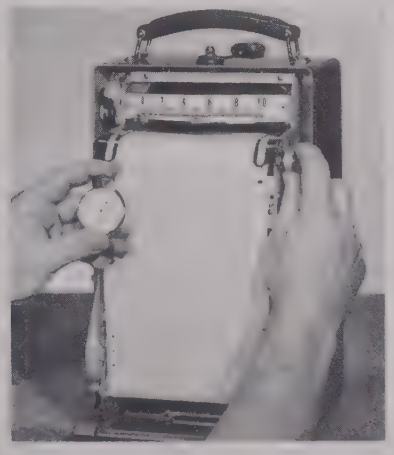

Fig. 23 – Turn the knurled set knob ahead until the correct time of day appears under the pen point. Turn the chart drive "Start-Stop" switch on.

Fig. 24 – Swing the pen across the chart to check for proper inking. Make sure pen point is at right angles to the chart. Now the measuring element, chronograph pens, etc. can be connected (see connection diagrams) and the instrument is ready for use.

IS 20 - CHART DRIVE GENERAL INSTRUCTIONS

ESTERLINE-ANGUS CHART DRIVES are made for the sole purpose of feeding the record chart at various speeds. The instruction plate on the front of all standard power drives shows the path traveled by the chart, change gears to use for each standard speed, and how to start and stop the drive. Change gears are stored on a clip at the upper left corner of the drive; change gears for special speeds, if any, are stored at the upper right corner. In changing gears, the keyway in the hub must engage the key on the shaft and the knurled nut holding each gear must be tight. DO NO PRY GEARS OFF THE SHAFTS. A straight pull will avoid bending a shaft.

Table of Standard Chart Speeds and Corresponding Change Gears

Chart Speed Inches Per Hour or Minute	Change Gears		Color of Driver & Driven Change Gears
	No. of Teeth Driver	No. of Teeth Driven	
3/4	18	72	Gold
1-1/2	30	60	Green
3	45	45	Red
6	60	30	Green
12	72	18	Gold

Electric Shift – Drives equipped with an electric shift to change chart speeds automatically from inches per hour to inches per minute have a separate pair of terminals on the back of the recorder. Voltage and frequency of the electric shift are not always the same as that of the motors. Note the terminal markings and the connection diagram before connecting power to these terminals.

Coupling Drives – Every chart drive, except the Selsyn, has a shaft for coupling to an external source or to the phantom drive in a twin recorder. It is not desirable to couple two synchronous drives. If set to the same time of day and operated from the same source, they will stay synchronized. Motor-wound spring drives should not be coupled to each other but may be coupled to a phantom drive in a twin meter or to an external driving source.

Two hand-wound spring drives can be coupled to synchronize chart timing. The drives must be in good condition and timed accurately, or they may stop. Coupled drives will operate at both hour and minute feeds.

Couplings – A phantom coupling is suitable for coupling the power chart drive in a twin instrument to the phantom chart drive. It is made to spring over the coupling ball fittings and eliminate any lost motion or backlash between the two drives. It is not suitable for transmitting heavy torque and it does not take the place of the power couplings, such as those used for external motor drive devices. Excessive torque on a phantom coupling will damage it.

Adjusting Chart Guides – The chart guides are properly adjusted at the factory and the adjustment normally should not be changed. However, if the drive has been subjected to rough handling or been disassembled, readjustment will be necessary.

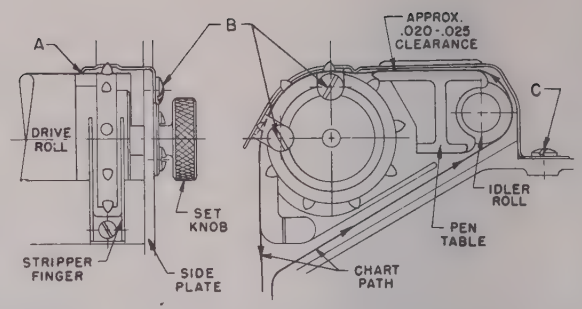

Fig. 25 - Chart guides are properly adjusted at the factory and require change only if repair work is done. Instructions for readjustment are contained in the accompanying text.

The correct position of the chart guides is evident when there is no tendency of the paper to be depressed into the grooves on the drive roll. The turned down edge "A" Fig. 25, should follow the contour of the drive roll but allow clearance for the chart paper, so that there is no drag on the paper. It may be necessary to loosen screws "B" (2 per guide) in order to facilitate this adjustment. Screw "C" may also be loosened when necessary to provide parallel clearance over the pen table and proper parallel positioning of chart guides with relation to the side plate.

Removing Chart Drives From Twin Cases- Before attempting to remove a chart drive from a twin case, the coupling must be disconnected by pushing the coupling endwise as far as it will go. If it is pushed to the right, the left-hand chart drive can be removed. Do not pull the drive out at an angle to disconnect from the coupling. This may damage the chart drive and the coupling. A phantom coupling, when properly located, should extend about the same amount over each coupling ball fitting.

Cleaning, Lubrication and Repair – The chart drive can be removed for cleaning and oiling by loosening the four corner mounting screws. The drive can then be pulled forward out of the case. Connections to any electrical features will be disconnected automatically when the drive is removed (except Selsyn, Style 102 and 101MS, which has screw terminals).

In general, oiling will be necessary after 1 to 3 years service, depending on the type of drive, the temperature at which the drive operates and the amount of dirt and dust which get into it. For specific lubrication information, refer to the instruction section (also included in this booklet) about your particular chart drive. After 5 to 10 years service, drives should be sent to the factory for complete overhauling.

Driving The Chart From An External Source – Hand-wound spring, motor-wound spring and synchronous chart drives are equipped with internal clutches so the chart can be driven from an external source or by an external motor attachment without damaging the internal mechanism. When the external source can reverse direction, the internal chart drive must also be equipped with a back-up clutch.

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IS 20, 15M
JUNE, 1960

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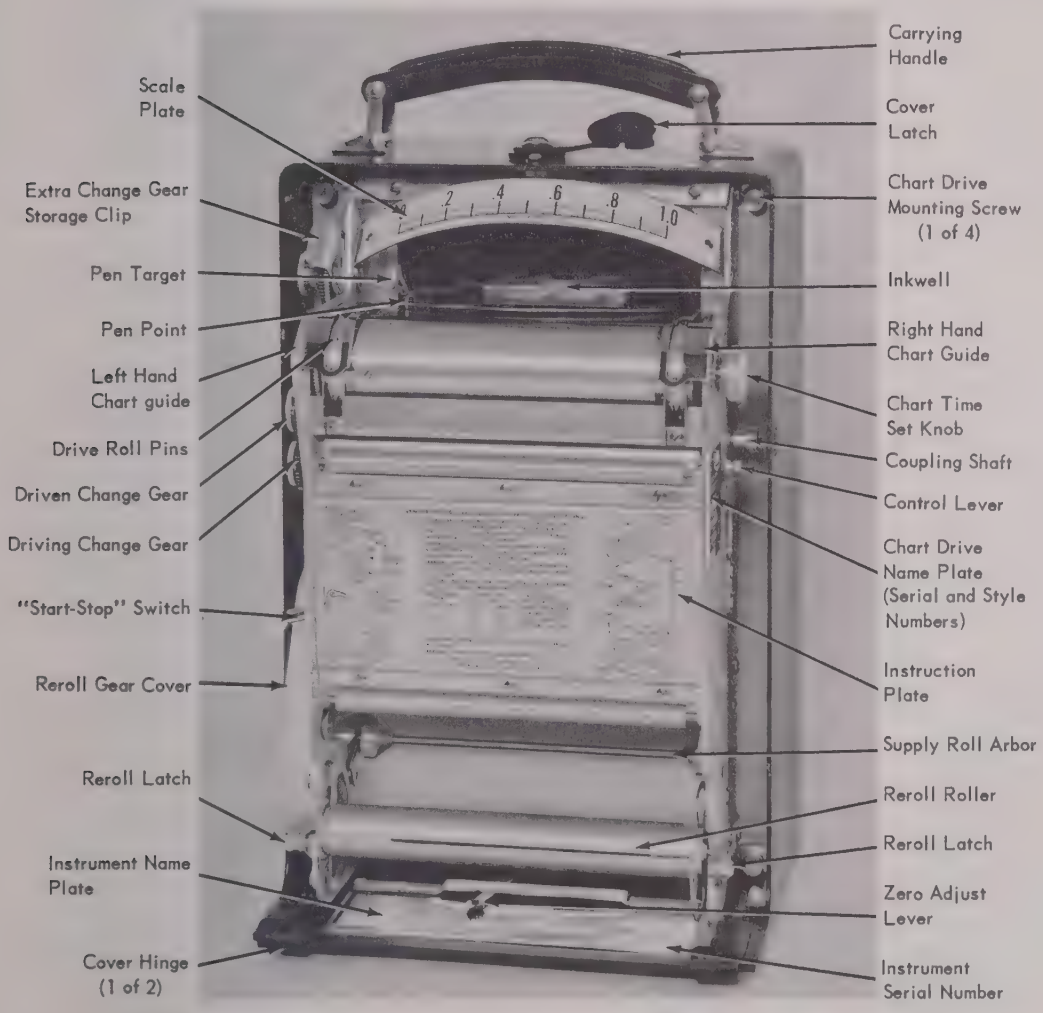
INSTRUCTIONS
FOR THE OPERATION AND CARE OF
ESTERLINE-ANGUS
SYNCHRONOUS CHART DRIVES

STYLES 90–M (TYPE NO. 4) AND 90–MS (TYPE NO. 4A)



Principal parts of a recorder with synchronous drive are shown above.

Each E-A synchronous chart drive contains two motors: the synchronous timing motor and an induction motor driving the reroll. Both motors are controlled by a single "Start-Stop" switch. The voltage and frequency ratings for these motors are shown on the chart drive nameplate and in the terminal markings on the back of the recorder. Operating limits are ± 10% of rated voltage. For complete electrical data, refer to the table on the back of this sheet.

Unwinding the Reroll Spring – The reroll gear train can be replaced as a unit or the reroll storage spring assembly only can be replaced. In either case, **be sure to let down the reroll spring before attempting disassembly.** With power off, hold the chart reroll roller in the hand and let it revolve slowly until it does not turn. Damage may result if disassembly is attempted with energy stored in the spring.

Table of Standard Chart Speeds

Style	TYPE	Standard Chart Speeds		Speed Change Mechanism
		Inches Per Hour	Inches Per Minute	
90-M	Synchronous, Hour and Minute Feed	¾, 1½, 3, 6, 12	¾, 1½, 3, 6, 12	Manual
90-MS	Synchronous, Hour and Minute Feed with Electric Shift	¾, 1½, 3, 6, 12	¾, 1½, 3, 6, 12	Manual or Electric

These drives are equipped with take-over clutch and through shaft for coupling to a phantom, external motor attachment or other external driving source. They should not be coupled to each other. If the external driving source can reverse, the internal drive must be equipped with a back-up clutch, and coupling must be on the right-hand side.

Electric Shift Coil – In synchronous chart drive style 90-MS, shifting from hour to minute feeds is accomplished by an electromagnet assembly. The voltage and frequency ratings for the electromagnet coil are shown in the terminal markings on the back of the recorder. For complete electrical data, refer to the table below.

Lubrication - Use E-A 40 Oil to lubricate all bearings. This oil is available from the Esterline-Angus Company in 1 oz. bottles and is for use on chart drives normally operated at temperatures of 20° to 100° F. Temperatures outside of this range require special lubrication. Consult the factory. Do not oil ratchets and pawls; they operate better if dry. In oiling, it is well to remember that too much lubrication is almost as bad as too little. **Do Not Over Oil.**

Synchronous Motors Are Lubricated For Life. Do Not Try To Relubricate. Removing motors from synchronous drives requires major disassembly and should be done only at the factory or in a well-equipped instrument shop.

Motor and Electric Shift Coil Data — Style 90-M and 90-MS Chart Drives

Rating	Combined Load of Timing and Reroll Motors			Reroll Motor Only			Electric Shift Coils*		
	VA	Watts	Amperes	VA	Watts	Amperes	VA	Watts	Amperes
6 Volts DC	.....	.....	.....	.....	.....	.....	.....	10	1.7
12 Volts DC	.....	.....	.....	.....	.....	.....	.....	10	0.8
24 Volts DC	.....	.....	.....	.....	.....	.....	.....	10	0.4
48 Volts DC	.....	.....	.....	.....	.....	.....	.....	10	0.2
125 Volts DC	.....	.....	.....	.....	.....	.....	.....	10	0.08
250 Volts DC	.....	.....	.....	.....	.....	.....	.....	10	0.04
120 Volts, 60 Cycles	23	10.5	0.19	15	6	0.13	13	5	0.11
240 Volts, 60 Cycles	23	10.5	0.09	15	6	0.07	13	5	0.06
120 Volts, 50 Cycles	26	13	0.21	15	6	0.13	16	6	0.14
240 Volts, 50 Cycles	26	13	0.11	15	6	0.07	16	6	0.07
120 Volts, 25 Cycles	17	9.5	0.14	9	4	0.08	13	6	0.11
240 Volts, 25 Cycles	17	9.5	0.07	9	4	0.04	13	6	0.06

*All AC shift coils are designed for continuous operation. DC shift coils should be energized intermittently, not more than 5 minutes on, followed by an equal off period.

THE ESTERLINE-ANGUS COMPANY

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IS 20 A, 7.5M
JUNE, 1960

PRINTED IN U.S.A.

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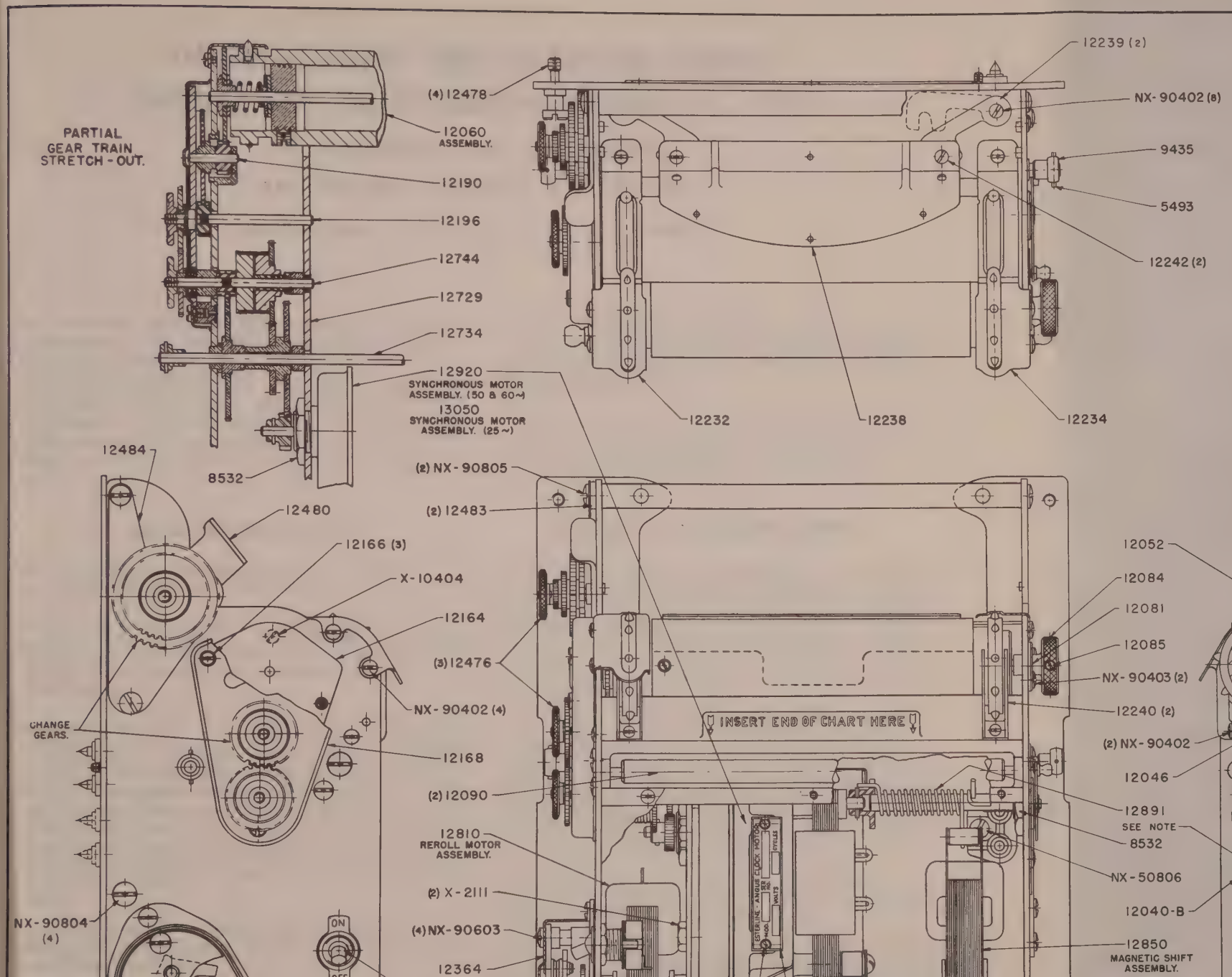
	0.08
	0.04
5	0.11
5	0.06
6	0.14
6	0.07
6	0.11



INSTRUCTIONS FOR ESTERLINE-ANGUS MODEL AW, ELECTRODYNAMOMETER TYPE

AC AMMETER, AC VOLTMETER, and AC-DC (Utility) VOLTMETER

Measuring Elements Style Nos. 316, 317, 327, 340, 341 and 342

The measuring elements in these recorders are similar in appearance. The differences between them are in the size of wire, number of turns and internal connection of the stationary and moving coils. The ranges of each style of measuring element and its electrical characteristics are shown on pages 6 and 7 of Catalog Section 30. The style number of the measuring element in your recorder is stamped on the measuring element nameplate and is shown on the data sheet in the front of the instruction book.

SETTING ZERO POSITION

The accuracy of these meters depends on having a correct setting of the zero position of the pen.

This setting should be checked periodically. If the pen does not rest on the zero line on the chart, with the meter disconnected, the zero should be reset by moving the zero adjusting lever located over the nameplate on the bottom of the case.

Setting the zero position accurately requires that the pen element be properly gauged for length, full of ink and correctly balanced. Instruments are shipped with the pen balanced, ready to use when the pen element is filled with ink. Changing the balance is accomplished by screwing the balance weights on the pen element nearer to or farther away from the knife edge pivot. The weights should be locked in place by screwing them tightly against each other. A properly balanced pen element will bounce off the chart when the pen table is tapped lightly with the finger.

Zero setting should be made by tapping the pen table and moving the zero lever until the pen rests exactly on the zero line on the chart.

DAMPING AND SWINGING SPEED

This instrument is equipped with adjustable damping. It has been set at the factory to the proper strength to prevent over-shooting on sudden swings. See Figs. 7 and 8, Catalog Section 30. This setting should not be changed unless special conditions warrant it and the change should be made by someone who understands the effect of changing the damping on recording instruments.

If it is desired to change the degree of damping, remove the chart drive from the instrument by loosening the four corner screws. This gives access to the damping mechanism at the lower end of the electrical measuring element. The two magnets are each pivoted on a vertical axis and held from turning by friction. Each magnet has a pointer projection on the lower edge. The pointer reads on a graduated scale marked 1 to 5. When the pointers are at No. 1, the least damping is obtained. No. 5 setting gives the heaviest damping. Both magnets must be set at the same number.

The magnets can be moved by turning them with the thumb and first finger. The degree of damping is designated by the number at which the pointer is set, and this number is shown on the data sheet as the damping number.

CARE OF THE MEASURING ELEMENT

If the moving element has a tendency to stick, and not swing freely, it is possible the trouble may be taken care of without returning the instrument to the factory. Examine the pen element clearance by pushing it across the chart: If the indicating pen target touches the scaleplate, carefully bend it to clear. Also, examine the vertical portion of the pen element where it dips into the inkwell opening. If this part is bent, it may rub against the inkwell.

If the sticking is not caused by the pen element rubbing, take out the chart drive by loosening the four corner screws and examine the magnetic damping mechanism at the bottom end of the measuring element. Turn the moving element slowly back and forth by means of the pen fork and note if the damper disc is rubbing. Rubbing may be caused by dirt or iron filings in the air gaps. Clean the air gaps by drawing a thin piece of sheet iron through them. Care should be taken not to bend the damper disc.

Avoid spilling of ink. Wipe off any spilled ink before it dries and keep dust and dirt off of the measuring element as much as possible.

The complete measuring element with terminal blocks and wiring can be removed from the case by taking out the four screws holding the terminal blocks and the three screws holding the measuring element. It is necessary to take switchboard and wall mounted instruments from the panel to reach these screws.

Esterline-Angus measuring elements are designed to be free from trouble and they will seldom require attention. Should the measuring element require major repairs or recalibration, it is best to return the instrument to the factory.

CHECKING CONNECTIONS AND CALIBRATION

Graphic instruments are sometimes suspected of reading incorrectly. On investigation, most such complaints are found to be due to incorrect connections, incorrect

assumptions as to what the meter should read, incorrect zero adjustment, or to an instrument which has suffered damage. The following instructions are for the purpose of enabling such situations to be corrected in the field and, thus, avoid the expense and loss of time in returning an instrument to the factory for examination or repair.

General - Before making any check of the instrument, the following points should be noted:

1 - With the electrical circuit disconnected, see that the pen is set correctly on zero (See paragraph "Setting Zero Position") and is the proper length and balance. (See "Care of the Inking System" General Instructions IS 10.) If the load circuit cannot be de-energized, in the case of an AC ammeter, short-circuit the current transformer and disconnect the meter. Then check and adjust the zero setting. In the case of a voltmeter, potential can always be removed by disconnecting one wire on the back of the meter.

2 - See that the moving element swings freely across the full scale. See "Care of the Measuring Element" above.

3 - In the case of a portable meter, see that it is reasonably level. If the instrument is tilted to one side or the other, the zero point will shift. If it is tilted forward or backward, this will "narrow" or will "spread" the scale. Small departures from level will not affect the readings appreciably, but an instrument that is sharply tilted will not read correctly.

4 - See that all connections are tight, both at the meter and at the terminals of any accessory devices, such as current transformers or potential transformers. If there are fuses in the potential circuits, see that these are intact and are tight in their clips.

Checking Connections - If the instrument is known to be in proper adjustment as described in the foregoing paragraphs, the next point is to check the correctness of the connections. They should be checked against the connection diagrams furnished in the instruction book. An AC ammeter must be connected in series with any other device fed by the same current transformer. A voltmeter must be connected in parallel with any other device fed by the same potential transformer.

Current and Potential Transformers - Check the ratio of current or potential transformers. The ratios involved in the meter calibration (permanently installed instruments) are shown on the data sheet.

Make certain that any current or potential transformer has adequate capacity to handle the instrument burden without introducing appreciable error. This is especially important when using split-core current transformers with ratio lower than 300:5.

Checking Readings Against Other Instruments - Sometimes the accuracy of a recorder is questioned because its readings do not agree with those of indicating meters installed on the switchboard in the same circuit. First, make sure that the connections to the recorder are correct. Second, make sure that the indicators are correctly connected and are correct in calibration. We not infrequently find indicators that are reading incorrectly because of incorrect circuit connections or because they have been overloaded, or suffered other damage. Sometimes this is not discovered until a recorder is connected in the same circuit and a direct comparison made.

Effects of Stray Fields - Due to the astatic internal connection of ammeters and voltmeters, most stray field effects are cancelled off, and it is only when bus bars, circuit breakers or the like, carrying several thousand amperes, are located within a foot or two of the meter that trouble may be experienced. The only cure is to move the meter away from heavy-current-carrying parts. An alternative, but less satisfactory, method is to shield the meter either by an open-faced iron box completely surrounding the recorder except in front, or by placing a plate of soft iron behind the recorder, between it and the current carrying part. The plate should extend beyond the meter several inches in all directions. This is a makeshift but is sometimes useful when no other solution is practical due to space limitations.

Checking Meter Resistance - After making all of the foregoing checks, if the reading of the meter is still doubted, or if it is known to have suffered damage as by flood or overload, a voltmeter can be checked by measuring its resistance. The instrument data sheet shows the resistance of the measuring element itself and the multiplier resistances. With a Wheatstone bridge or portable ohmmeter, these resistances can be checked. If the values differ markedly from those shown on the Data Sheet, repair work is required.

Very little can be learned by trying to check the resistance of an AC ammeter except to show whether it is open circuited.

Checking Calibration - The only satisfactory way of checking voltmeter calibration is against another standard instrument. An AC ammeter can be checked, independent of its current transformer, either against a standard meter or against the approximately known current of a lamp bank or other resistance load.

ORDERING PARTS

When ordering parts for this recorder, always give the serial number. See print No. 8500 in this book for assembly drawing of the measuring element and part numbers.

THE ESTERLINE-ANGUS COMPANY

Pioneers in the Manufacture of Graphic Instruments

P. O. BOX 596, INDIANAPOLIS 6, INDIANA

IS 30, 1M
FEBRUARY, 1960

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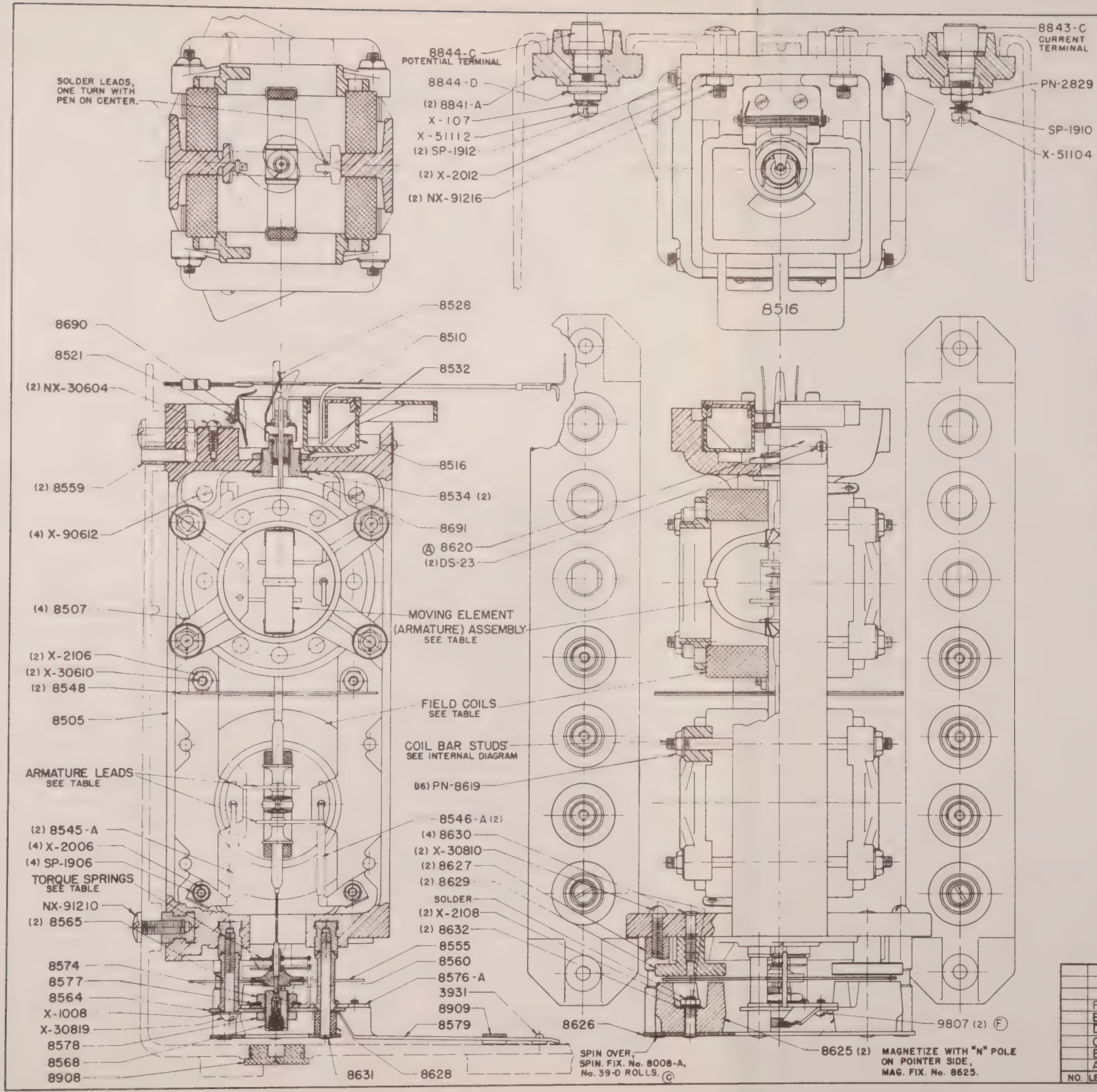


MOVEMENT ASSEMBLY TABLE

MOVEMENT SPECIFICATION NUMBER	PART NUMBERS: MOVING ELEMENT	ARMATURE ASSEMBLY	SPRING ASSEMBLY	FIELD COILS	COIL LEADS	STANDARD DAMPING NUMBER	CALIBRATION	INTERNAL DIAGRAM WIRING NUMBER
312-A*	8526-B	8535-A	8722-C	8551	8596-A	3-A	5 AMPS-100 MV	D-827
316-A	8526-E	8535-D	8722-E	8551	8596-A	3-A	5 AMPS.	D-831
316-C	8526-E	8535-D	8722-E	8551	8596-A	3-A	10 AMPS	D-832
316-D	8526-E	8535-D	8722-E	8551	8596-A	3-A	20 AMPS	D-833
316-B	8526-E	8535-D	8722-E	8551	8596-A	3-A	5 AND 10 AMPS	D-834
317-A	8526-E	8535-D	8722-E	8550-A	8596-A	3-A	4 AND 4 5 AMPS	D-835
317-B	8526-E	8535-D	8722-E	8550-A	8596-A	3-A	6.5 AMPS	D-836
322-A*	8526-B	8535-A	8722-C	8551	8596-A	3-A	5 AMPS-100 MV	D-801
326-A	8526-C	8535-B	8722-B	8550-A	8596-B	3.5-A	5 AMPS	D-802
326-B	8526-C	8535-B	8722-B	8550-A	8596-B	3.5-A	7.5 OR 10 AMPS	D-816
326-C	8526-C	8535-B	8722-B	8550-A	8596-B	3.5-A	5 AND 10 AMPS.	D-815
327-A	8526-C	8535-B	8722-B	8550-B	8596-B	3.5-A	2.5 AMPS	D-814
328-A	8526-C	8535-B	8722-B	8551	8596-B	3.5-A	15 AMPS.	D-816
328-B	8526-C	8535-B	8722-B	8551	8596-B	3.5-A	20 AMPS	D-817
330-A*	8526-A	8535-C	8722-B	8550-A	8596-A	3.5-A	5 AMPS	D-800
330-B*	8526-A	8535-C	8722-B	8550-A	8596-A	3.5-A	10 AMPS	D-818
332-A*	8526-B	8535-A	8722-C	8551	8596-A	3-A	5-10 AMPS. 3 PH. 4 W.	D-825
334-A*	8526-B	8535-A	8722-C	8551	8596-A	3-A	5 TO 10 AMPS.	D-826
340-A	8526-D	8535-C	8722-C	8553	8596-A	3-A	150 V A.C. OR 150 V. D.C.	D-803
340-B	8526-D	8535-C	8722-C	8553	8596-A	3-A	150 V UTILITY	D-804
340-C	8526-D	8535-C	8722-C	8553	8596-A	3-A	125 V. A.C	D-821
341-A	8526-D	8535-C	8722-C	8553	8596-A	3-A	50-120 V. A.C.	D-819
342-A	8526-D	8535-C	8722-C	8553	8596-A	3-A	100-143 V. A.C	D-843
342-B	8526-D	8535-C	8722-C	8553	8596-A	3-A	150 V. 400 CY.	D-844
342-C	8526-D	8535-C	8722-C	8553	8596-A	3-A	.2 AMPS.	D-845
375-A	8526-D	8535-C	8722-C	8553†	8596-A	3-A	SEE DATA SHEET	S-2086

*THESE MOVEMENTS HAVE SHIELD BETWEEN ELEMENTS.

†WITHOUT 8586 CORRECTORS.

NO.	LET.	CHANGE	DATE	AP.
	F	WAS NX-30603	3-30-59	
	E	TABLE REVISED	1-7-49	
	D	375 M'V'M'T ADDED	10-22-47	
	C	WAS No. 3 ROLLS.	2-4-46	
	B	WAS 8842-A	12-31-45	DR. CWS
	A	WAS ENGRAVE	10-19-45	CH.

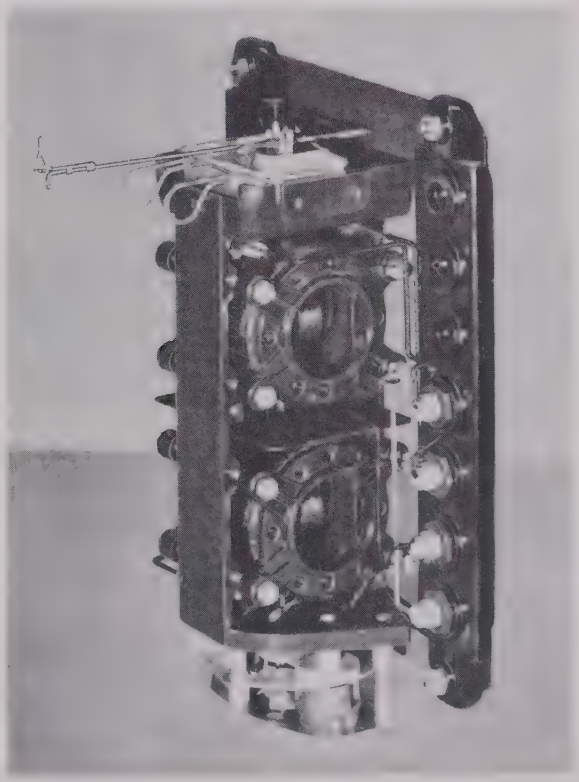
THE ESTERLINE-ANGUS CO., INC.
INDIANAPOLIS, IND.

ELECTRODYNAMOMETER MOVEMENT ASSEMBLY.

SCALE: FULL SIZE. 4/6/42 No. 8500

ESTERLINE-ANGUS
Recording

Alternating Current Ammeters
Alternating Current Voltmeters
AC-DC (Utility) Voltmeters
ELECTRODYNAMOMETER TYPE



For over fifty years our design engineers have concentrated their efforts on building the best recording instruments. Since no recorder can produce records any more accurate than its measuring element can measure, a considerable portion of those efforts has gone into perfecting the measuring element. In the following pages, we are concerned with the electrodynamometer measuring elements used in AC ammeters, AC voltmeters and AC-DC (Utility) voltmeters. Similar electrodynamometer measuring elements are used in wattmeters, varmeters, KVA, power factor and frequency recorders.

Catalog Section 30
(August 1958)

AC Ammeters, AC and AC-DC (Utility) Voltmeters using Electrodynamometer Measuring Elements

An electrodynamometer measuring element consists of two pairs of stationary coils, called field coils, and two moving coils on a single staff, called armature coils. These parts are held in the proper relation to each other by a molded bakelite frame, Fig. 1. The top of the bakelite molding forms a cavity for holding the inkwell, Fig. 2, and has two drain tubes that carry away any spilled ink. The upper bearing support is sealed so that ink cannot flow down around it.

The armature coils are carried on a staff, Fig. 1, which has a pen fork on its upper end to hold the pen element. Immediately below the pen fork is a canopy that covers the upper bearing and prevents any extraneous material from getting into the bearing or traveling down the staff. Near the lower end of the staff is an aluminum vane that rotates in the field of two adjustable damping magnets, to control response speed. The lower tip of the moving member is a hardened steel, hemispherical pivot, which rests in a sapphire jewel. This jewel is spring mounted, protecting it against injury from mechanical shock.

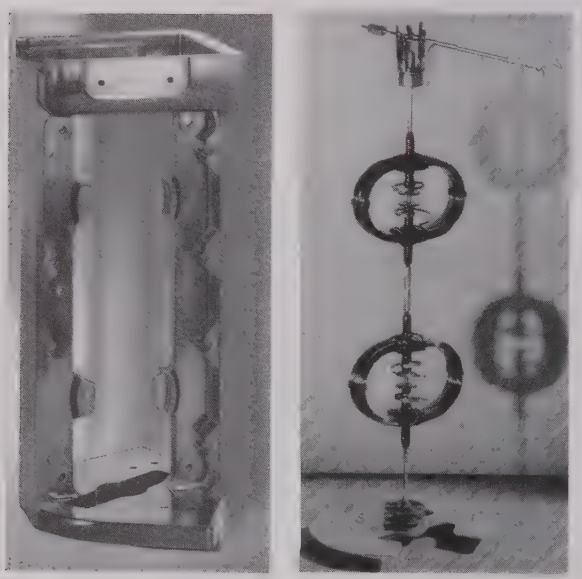


Fig. 1—*The molded bakelite frame (left) forms a rigid support for the fixed and moving coils of the measuring element and provides a high degree of insulation between current carrying parts. The moving element or armature of the dynamometer (right) consists of two coils, mounted on a solid staff which carries the pen fork, restraining springs, damper vane and steel pivot. The pen element, shown in place, is easily taken out or replaced without tools*

Each measuring element has its damping magnets set properly at the factory for the weight and torque of its moving system. When it is necessary, to meet specific operating conditions, the magnet settings can be changed in the field. The effect of different magnet settings and the flexibility of the response that can be obtained, are shown in Figs. 7 and 8.

AC ammeters and voltmeters of the dynamometer type record RMS values independent of wave form. The magnetic circuits are air-cored. The absence of iron makes these measuring elements completely insensitive to ordinary variations in power system frequency. Some of them are accurate over the entire range of 25-400 cycles. For higher frequencies, lower burden, uniform scale or a combination ammeter-voltmeter, the rectifier type instruments in Catalog Section 48 are recommended.

The problem of maintaining a fixed relation between stationary and moving coils is solved by the molded bakelite frame. The fixed relation is so accurately maintained that a measuring element can be disassembled and put back together without changing its calibration. This frame also helps to solve another problem, that of providing adequate insulation between the various parts. How well that is accomplished is attested by the fact that the measuring elements withstand a 5000 volt AC insulation test for one minute between all current carrying parts and ground.

The measuring element, with its terminal boards, is a complete unit which can be installed in or removed from the recorder case without disturbing its electrical connections. This measuring unit is also interchangeable with other elements, such as the permanent-magnet, moving-coil type. While E-A dynamometer measuring elements are essentially two-element devices, they are used as single element meters, in AC ammeters, and AC and AC-DC voltmeters. The two halves of the measuring element are connected astatically to eliminate external field effects.

AC Ammeters

In an AC ammeter, both the stationary and moving coils are fed through one pair of leads, connected into the measured circuit or to the secondary of a current transformer.

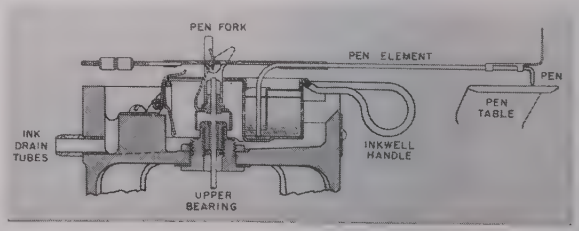


Fig. 2—*Cross-sectioned view shows the top of the measuring element frame, with inkwell and pen element in place, drain tubes that prevent spilled ink from reaching any current-carrying parts, as well as the canopy protecting the upper bearing*

There are two styles of AC ammeter measuring elements. Style No. 316 is used for 0-5, 0-5/10, 0-7.5, 0-10, 0-15, and 0-20 ampere instruments. It has a small, internal current transformer which supplies the current to the moving coils. This transformer protects the instrument during heavy overloads of short duration and makes possible an instrument having a low burden, as shown in the table on page 6.

Measuring element Style No. 317 is similar to No. 316 but is modified to produce odd full scale ranges that cannot be obtained with the No. 316 element. No. 316 can be used on 25-400 cycles and No. 317 on 25-240 cycles, all with 1% accuracy. The No. 316 and 317 elements cannot be used on DC because of the internal transformer.

Leads

Lead lengths are not critical and long leads may be used almost at will, without affecting calibration of the meter. Where it is known that the current transformer is loaded nearly to capacity, long leads should not be used without calculating the additional burden they will impose.

Scales and Charts

When an AC ammeter is to be permanently connected to one current transformer, the scale and chart range should correspond to the primary rating of the transformer. Direct reading charts can be furnished for nearly all applications. (See 1300 series charts in catalog section 90.) Portable instruments are usually supplied with a 0-5 ampere scale and chart, and a multiplying factor (equal to the current transformer ratio) is used to interpret the chart.

Scales and charts are approximately quadratic, being spread out near full scale and condensed near zero. Because of this feature, it is impossible to read values below one-third of full scale accurately but the useful part of the scale can be read within one percent of full scale value.

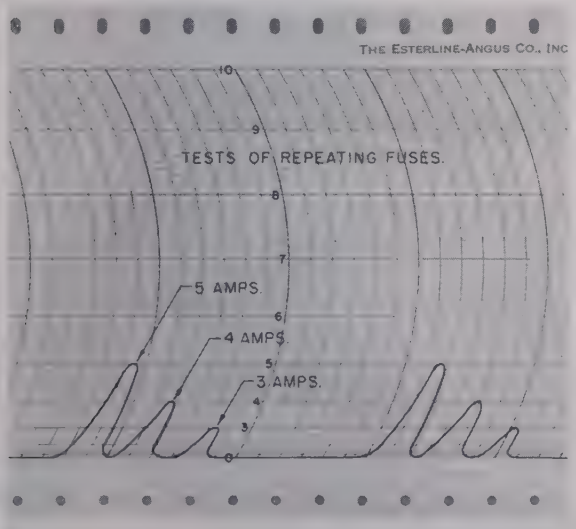


FIG. 3—*Graphic ammeter chart of the operation of a 25,000 volt repeating fuse, shows tests of 3, 4 and 5-ampere elements*

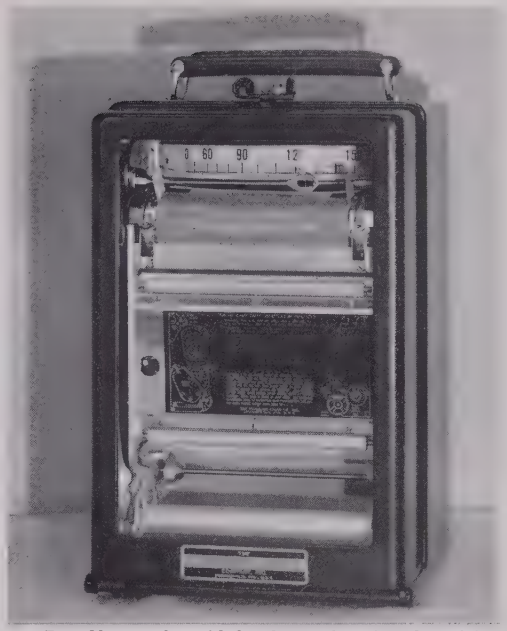


FIG. 4—*Portable recorder with hand-wound spring chart drive, pen element in tie-up card, ready to be packed for shipment*

Ammeter vs. Wattmeter

It is often necessary to choose between an AC ammeter and AC wattmeter to record some particular condition. Where current is the governing factor, as in balancing phases of a transformer bank or distribution system, studying cable heating, etc., the AC ammeter is the correct choice because it records the value of the key factor in the situation being investigated.

Where work being done or the power load on equipment, particularly AC motors, is the paramount condition to be studied, the AC wattmeter is the correct choice. The wattmeter takes into account changes in line voltage and power factor and its record shows true power input accurately. AC ammeters cannot do this and it is possible to misinterpret ammeter records unless these facts are borne in mind. An example will serve to show the difference between ammeter and wattmeter records. The KW input to a squirrel cage induction motor at no load will usually be less than 10% of the full load power, while the current will be anywhere from 25 to as much as 50% of full load current. Power varies over a wider range than current and gives a better picture of load characteristics.

Motor starting currents are handled better by a wattmeter, since the starting surge is very low power factor. When an ammeter is used, the starting current can be kept off the record by short circuiting the recorder during starting or using a time delay relay, although this precaution is considered necessary only on certain unusual applications.

Switching Ammeters

When an ammeter is to be switched from one circuit to another, the switch must short-circuit one current transformer before it disconnects the ammeter and connects it to another current transformer.

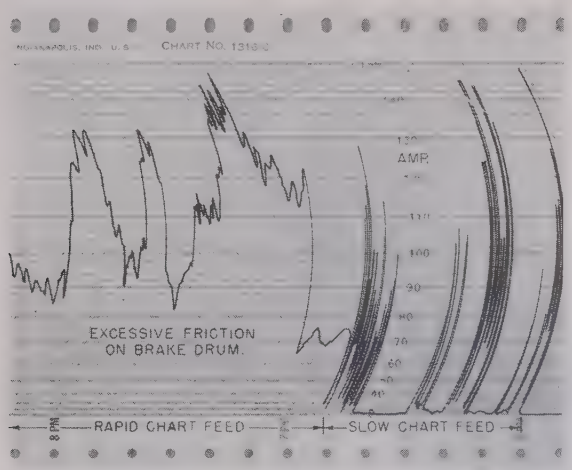


FIG. 5—*Five similar mine hoists were tested and four performed satisfactorily. One produced this record, shown with both slow and rapid chart speed. Investigation located a high spot on the brake drum, rubbing on the band during each revolution*

Applications

Some suggested uses, both for portable and permanently installed AC ammeters are in recording:

- Unbalance in secondary networks
- Grounded neutral fault currents
- Phase balance in office building distribution systems
- Currents in cables, feeders, buses to find overloaded elements of a system
- Transformer loads to study heating
- Welding, continuous or spot
- Operating cycles, where the record is not being interpreted in terms of work done
- Repetitious operations, such as grinding and polishing, machine tool time studies
- Water velocity in large ducts or conduits (salt injection method)
- Dynamic braking
- Fuse and circuit breaker operating values

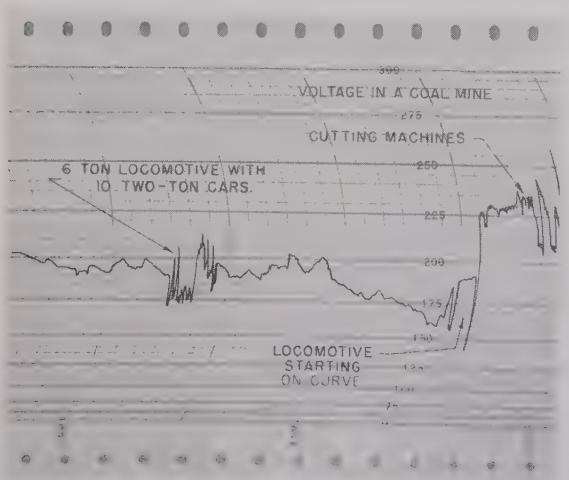


FIG. 6—*Voltage record from a feeder in a coal mine. Locomotives could not pull the loads because the voltage dropped from 275 to 140 when the locomotive started*

AC and AC-DC (Utility) Voltmeters

Voltmeters using dynamometer measuring elements are of two types, those intended for AC use on a specific frequency and those intended for use on DC and multiple frequency AC. Internal coil connections are shown on page 7. A tapped resistor effects the proper calibration for the voltage ranges provided. This resistor is housed in a multiplier box on the back of portable and flush meters and separately mounted for meters in wall or front switchboard cases.

Three styles of measuring elements are available to cover the ranges shown on page 7. Style No. 340 is used in AC voltmeters calibrated for a specific frequency, usually 25, 50 or 60 cycles. It can be adjusted

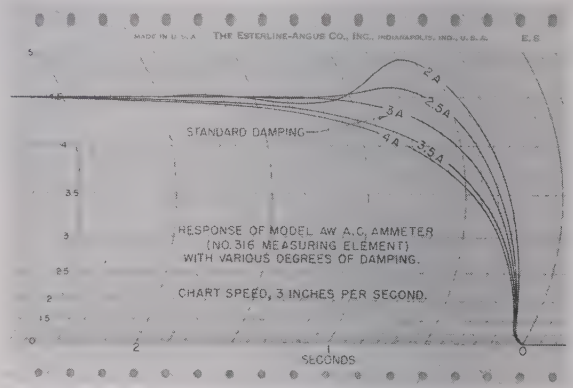


FIG. 7—*Standard damping of ammeters is somewhat heavier than critical and gives a speed of response of about 1.15 seconds*

for any full scale value between 143 and 800 volts. The same measuring element, with a frequency compensating network, is used in AC-DC (Utility) voltmeters. Voltage ranges from 150 to 800 volts are available. These utility voltmeters are calibrated for DC and for AC frequencies of 25-60 cycles. This measuring element draws 0.13 ampere at full scale.

Style No. 341 is available to provide ranges between 0-50 and 0-250 volts. The current drawn by this lower voltage element is 0.38 ampere.

Style No. 342 element can be calibrated for any range between 0-100 and 0-600 volts, 25, 50 or 60 cycles. Full scale current is 0.18 ampere.

For ranges below those for which a standard measuring element can be calibrated, it is necessary to use a meter with a 0-150 volt range (No. 340 measuring element) and a step-up potential transformer. A potential transformer with primary ranges of 25, 50 and 75 volts to 150 volts secondary is available. For ranges down to 0-5 volts, 60 cycles, use the rectifier type AC voltmeter with 0-150 volt range and a 5/15/30: 150 volt step-up potential transformer. See Catalog Section 48.

Leads

Lead resistance is not a critical part of the measuring circuit and long leads are frequently used. Binding post terminals may be used on portable instruments instead of standard 5-foot, plug type leads.

Scales and Charts

Permanently mounted instruments are provided with a scale and chart to place the line voltage at a convenient point on the chart. For example, a scale of 0-150 volts is used on 120 volt circuits, 0-300 volts on 240 volt circuits and 0-600 volts on 480 volt circuits. When potential transformers are used, the recorder scale and chart range can be selected for either primary or secondary values.

Portable multi-range meters should have a scale and chart range corresponding to the lowest self-contained range or the range that will be most widely used. For example, a 0-150/300/600 volt recorder, used for general purpose testing, should have a 0-150 volt scale and chart.

Scales and charts are approximately quadratic, (1300 series in catalog section 90). The normal record

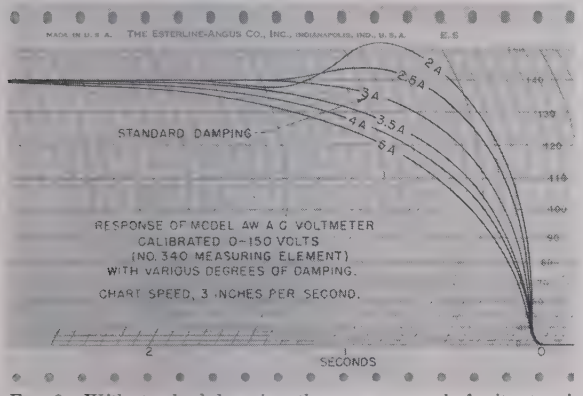


FIG. 8—*With standard damping, the response speed of voltmeters is about 1.3 seconds*

should be kept between ½ and ¾ scale in the open portion of the scale, and the lowest useful value to be recorded must be above ⅓ full scale.

Applications

The uses of voltmeters, while simple to state, are very important. Probably more plant operating troubles result from improper voltage than any other single cause. Voltage surveys with portable meters, plus permanently mounted recorders at strategic points will show when operating conditions must be improved, to avoid future trouble.

Some suggested applications are studies of:

- Line, bus and feeder voltage records on power systems and plant distribution systems
- Faults (with quick-trip chart drive)
- Customer complaints
- Operating troubles: motors fail to start, blown fuses, overheating
- Welding (lower voltage meters)
- Safety equipment tests (rubber gloves, sleeves, etc.)
- Operation of voltage regulators
- Power rectifier input and output voltages

Rectifier Ammeters and Voltmeters

Rectifier type AC instruments, described in Catalog Section 48, are suggested where:

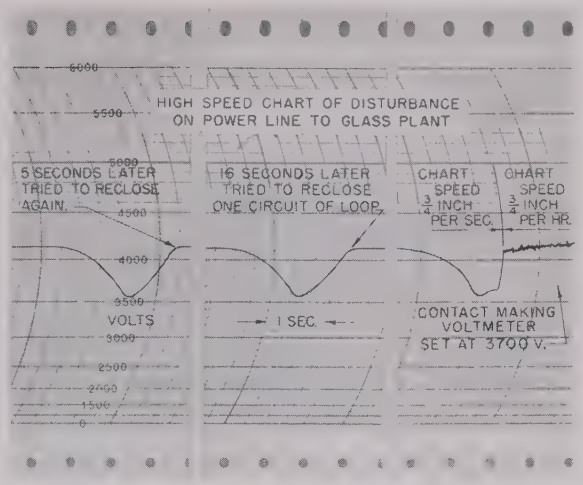


FIG. 9—*This record was taken in a glass plant with a voltmeter having a Type R external motor drive. Continuity of service at the proper voltage is extremely important in such plants. Failure may cause loss of product and extensive damage to equipment*

1—a low burden is necessary, as when using a low-range, split-core current transformer.

2—measuring the AC voltage of a low power source.

3—a multi-purpose instrument is advantageous, such as a combination AC-DC ammeter-voltmeter.

4—voltage ranges down to 0-5 volts are required. Use 0-150 volt range on the rectifier recorder and a 5/15/30:150 volt, 60 cycle, step-up potential transformer.

These instruments have the advantage of being usable over a wide range of frequency (50-800 cycles) and they have uniformly divided scales and charts. Rectifier recorders read average values and are scaled in RMS values based on sine wave. Changing wave form changes the ratio of average to RMS values, but such variations on commercial systems are usually slight.

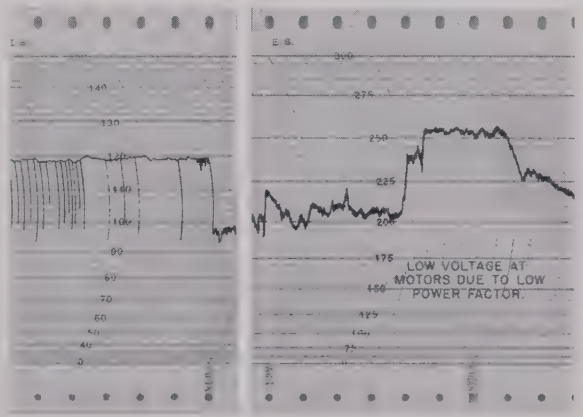


FIG. 10—*The effect of grounds on a lighting line where it passed through trees is shown at the left. Voltage, in the right-hand chart, was normal during the noon period, but dropped as low as 200 when the plant resumed work. Troubles due to low voltage evidence themselves in blown fuses, overheated motors, and decrease in production*

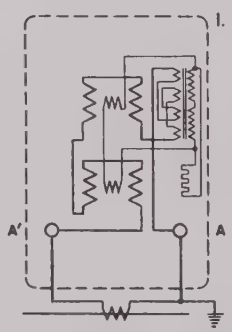
Model AW AC Ammeters

Two-element Astatic Electrodynamometer Type
Measuring Elements Nos. 316 and 317

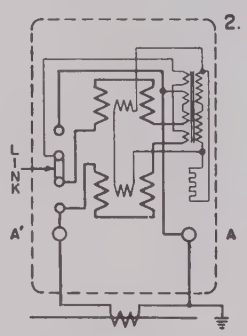
Standard Ampere Range	Measuring Element Style No.	Burden in VA		Impedance in Ohms		Power Factor		Voltage Drop		Frequency Limits for 1% Accuracy	Calibration Limits*	
		25 cy.	60 cy.	25 cy.	60 cy.	25 cy.	60 cy.	25 cy.	60 cy.		Min.	Max.
0-5†	316	6.6	9.5	0.26	0.38	0.98	0.68	1.3	1.9	25-400	0- 4.8	0- 5.5
0-7.5	316	10.5	15.0	0.19	0.27	0.90	0.63	1.4	2.0	25-240	0- 6.9	0- 7.6
0-10	316	6.6	9.5	0.07	0.10	0.98	0.68	0.70	1.0	25-400	0- 9.6	0-11
0-15	316	10.5	15.0	0.047	0.067	0.90	0.63	0.70	1.0	25-240	0-13.8	0-15.2
0-20	316	6.6	9.5	0.007	0.024	0.98	0.68	0.33	0.48	25-400	0-19.2	0-22
0-5/10												
5 range	316	6.6	9.5	0.26	0.38	0.98	0.68	1.3	1.9	25-400		
10 range	316	6.6	9.5	0.07	0.10	0.98	0.68	0.70	1.0	25-400		

†The burden of the 0-5 ampere meter (with 316 measuring element) is 22 VA at 180 cycles; 45 VA at 400 cycles.

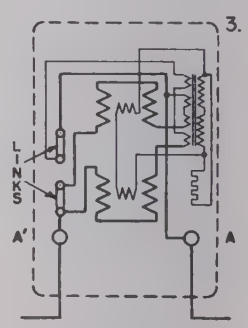
*See also Special Ranges below.



Internal and external wiring diagram, 0-5 ampere AC ammeter with current transformer



Dual-range 0-5/10 ampere AC ammeter connected on 5-ampere range with current transformer



Dual-range 0-5/10 ampere AC ammeter connected for 10 amperes

Charts—Approximately quadratic, 1300 series, refer to catalog section 90.

Scales—To match any 1300 series chart. Lowest readable current is about ⅓ full scale. On dual-range meters, scale should match lower range. On permanently mounted meters, the scale should be selected so that the normal record will be about ¾ full scale and the maximum value less than full scale.

Zero—Left-hand only. Meter has no polarity.

Multiranges—Only the dual-range meters listed in table.

Leads—Furnished only with portable type. Standard portable leads are 5-feet long. Dual-range meters have only two leads, see diagrams 2 and 3, above.

Binding Posts—Can be furnished instead of leads on portables.

Multipliers—None required.

Damping—Adjustable magnets and damper vane.

Response Speed—With standard damping, time required for pen to complete swing one way—1.15 second.

Dielectric Test—5000 volts, 60 cycles, for one minute.

Guaranteed Accuracy—1% of full scale current.

Overload Capacity—5 ampere meter will carry 9 amperes continuously; 200 amperes for 1 second.

Special Ranges—Any single range meter within the calibration limits in table above. Also odd full scale calibrations of 3.7-4.7, 5.6-6.1, 6.2-6.8 and 7.7-8.5 A are available, using measuring element No. 317.

DC Operation—Measuring elements Nos. 316 and 317 have an internal current transformer and cannot be used on DC.

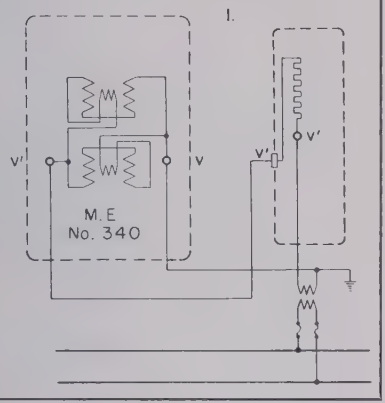
Current transformers—Must be used for currents exceeding the self-contained range, and on circuits above 800 volts.

Model AW AC Voltmeters

Two-element Astatic Electrodynamometer Type
For use on a single frequency within limits shown in Table I
Measuring Elements Nos. 340, 341 and 342

Range in Volts

0-50	0-150
0-75	0-300
0-100	0-600
0-125▲	0-750
0-150/300	
0-150/600	
0-300/600	
0-150/300/600	
0-150/300/750	
0-150/300/600/750	

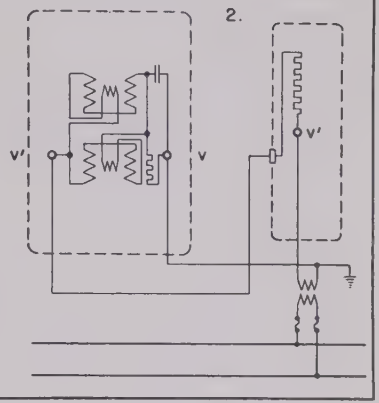


Model AW AC-DC (Utility) Voltmeters

Two-element Astatic Electrodynamometer Type
For interchangeable use on DC to 60 cycles AC
Measuring Element No. 340-B, with frequency compensating network

Range in Volts

0-150
0-300
0-600
0-750
0-150/300
0-150/600
0-300/600
0-150/300/750
0-150/300/600/750



▲No chart is available for the 0-125 volt range.

TABLE I—*Average Electrical Data—AC Voltmeters*

Measuring Element Number	Range in Volts	Approximate Full Scale Current Amperes	Approximate Reading of Standard 60 cycle Meter Used on Various Frequencies		
			DC	25 cy.	60 cy.
340†	0-150*	0.13	1.03	1.02	1.00
340	0-300	0.13	1.01	1.01	1.00
340	0-600	0.13	1.00	1.00	1.00
340	0-750	0.13	1.00	1.00	1.00
341	0- 50	0.38	1.05	1.04	1.00
341	0- 75	0.38	1.02	1.02	1.00
341	0-150	0.38	1.01	1.01	1.00
341	0-200	0.38	1.00	1.00	1.00
341	0-250	0.38	1.00	1.00	1.00
342	0-100	0.18	1.01	1.01	1.00
342	0-125▲	0.18	1.01	1.01	1.00
342	0-150	0.18	1.00	1.00	1.00
342	0-300	0.18	1.00	1.00	1.00
342	0-600	0.18	1.00	1.00	1.00

*This is the measuring element commonly used in AC Voltmeters for 25, 50 or 60 cycle service. Minimum calibration limit 0-143 volts.
▲No chart is available for the 0-125 volt range.
†Burden of 150 volt instrument at 120 volts, 60 cycles is 12.5 volt-amperes.

TABLE II—*Average Electrical Data—AC-DC (Utility) Voltmeters*

Range in Volts	Reading of Standard Meter Used on Various Frequencies		
	DC	25 cy.	60 cy.
0-150†	1.00	1.00	1.00
0-300	1.00	1.00	1.00
0-600	1.00	1.00	1.00
0-750	1.00	1.00	1.00

†Burden of 150 volt instrument at 120 volts, 60 cycles is 12.5 volt-amperes

Charts—Approximately quadratic, 1300 series, refer to catalog section 90.
Scales—To match any 1300 series chart. Lowest readable voltage is about ⅓ full scale. On multi-range instruments, scale should match lowest range or range most often used.
Zero—Left-hand only. Meter has no polarity.
Multi-ranges—A number of combinations not listed can be supplied.
Leads—Furnished only with portable type. Standard portable leads are 5-feet long.
Binding Posts—Can be furnished instead of leads on portables.
Multipliers—Portable and flush meters have multiplier mounted on case back. Front switchboard and wall type have one separate standard size multiplier.
Damping—Adjustable magnets and damper vane.
Response Speed—With standard damping, time required for pen to complete swing one way—1.3 seconds.
Dielectric Test—5000 volts, 60 cycles, for one minute.
Guaranteed Accuracy—1% of full scale voltage.
Potential Transformers—Required above 800 volts AC.
Special Ranges—AC or AC-DC: any intermediate ranges can be furnished. For ranges below those listed, consult factory. Consideration should be given to rectifier recorders, Catalog Section 48, for which a 5/15/30:150 volt, 60 cycle, step-up transformer is available.

Cases

Portable, wall, flush and front switchboard single case styles are available and all but portable are also furnished in twin mounting. The case bodies are die-cast, aluminum alloy, finished with dull black, baked enamel. Flush cases are equipped with fluorescent lighting for 120 volts, 60-cycles. For other frequencies, incandescent lighting is furnished.

Chart Drives

A large variety of chart drives provides the user with the utmost in flexibility to meet conditions in his particular plant. Briefly they are divided into three general classes:

Hand-wound spring
Motor-wound spring
Synchronous motor

Each type can provide chart speeds of ¾, 1½, 3, 6 and 12 inches per hour and per minute. The change from inches per hour to inches per minute can be made manually by means of a shift lever, or electrically, with the addition of a shift coil inside the chart drive.

Higher chart speeds are sometimes required to study short time intervals, and external motors, providing speeds of ¾, 1½ and 3 inches per second, can be supplied. For high speed fault recording, a special form of this external drive, called Type R, resets the chart to correct time of day after each high speed run.

When instruments are combined in twin cases, both charts can be driven by a single power chart drive, mounted in the right-hand half of the twin. The other half of the twin then uses a slave mechanism, called a phantom chart drive. Phantom drives can also be used where it is desired to drive the chart from an external source.

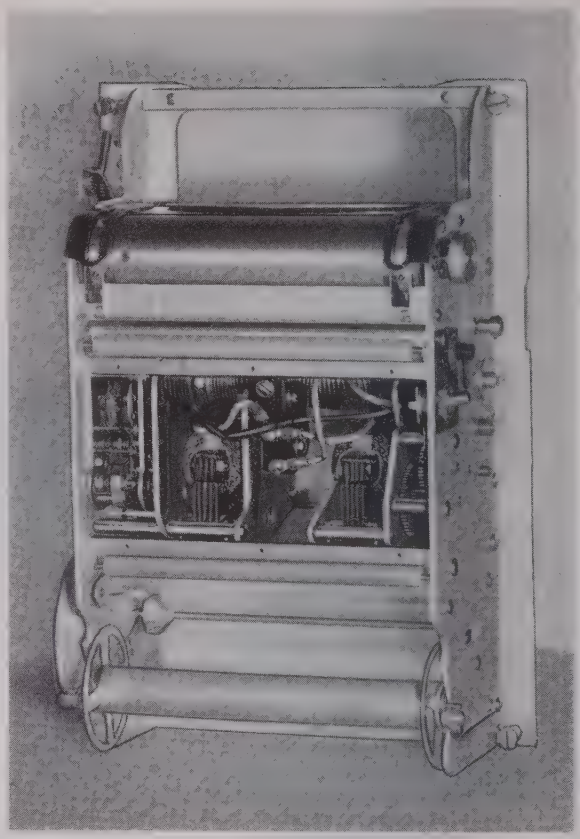


FIG. 11—*The motor-wound spring chart drive operates as a spring drive and the springs are wound periodically by motors. When the power goes off, operation will continue for at least five hours, at any standard hour feed, on the energy stored in the springs*

How to Order

Specify

1—Case Style (catalog section 15): Portable, Flush Switchboard, Front Switchboard, Wall mounting.

2—Chart Drive (catalog section 20): Hand-wound spring, Synchronous, Motor-wound spring. If electric give voltage and frequency. If electric hour-to-minute feed shift desired, give voltage and frequency.

3—Measuring Element: Full scale amperes or volts of the ranges desired. Frequency.

4—Scale and Chart: Range numbers desired on chart and scaleplate. Chart speed.

5—Current Transformer (catalog section 80): Ratio. Portable or switchboard. Are we to furnish?

6—Potential Transformer (catalog section 80): Ratio. Frequency. Portable or switchboard. Are we to furnish?

7—Accessories and Attachments (catalog section 80): Writing door, glass corner in case cover, right- and left-hand chronograph pens (give voltage and frequency), etc.

8—Supplies: (catalog section 90): Chart inspector, extra pen elements, pen points, pen point cleaner, charts, ink, carrying case, etc.

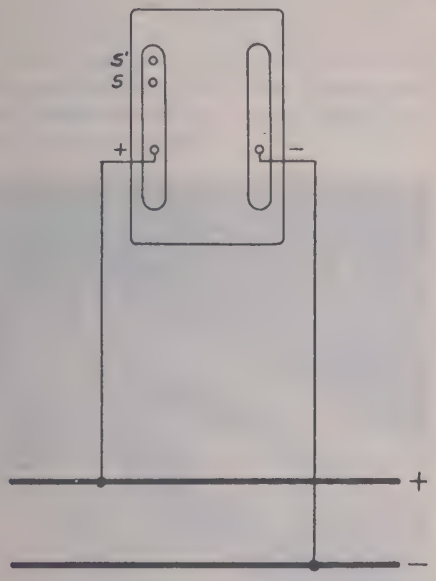
THE ESTERLINE-ANGUS COMPANY, INC.
Pioneers in the Manufacture of Graphic Instruments
P. O. BOX 596, INDIANAPOLIS 6, INDIANA

Diagram of Connections
for Model AW

Esterline-Angus Portable and Flush Type Graphic Voltmeter.

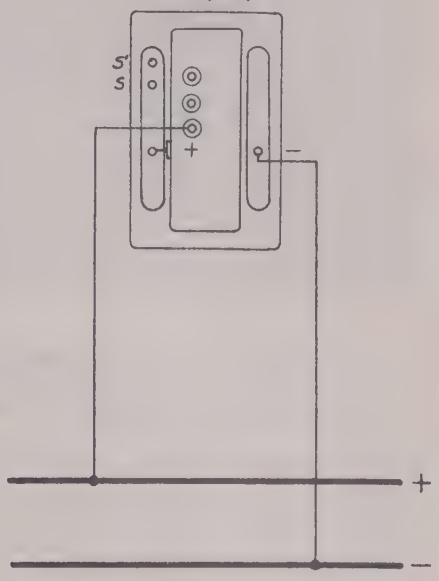
Back Views.

Fig. 1.



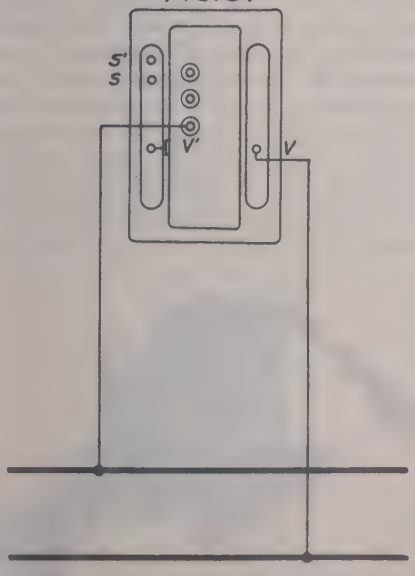
Direct Current
Without Multiplier.

Fig. 2.



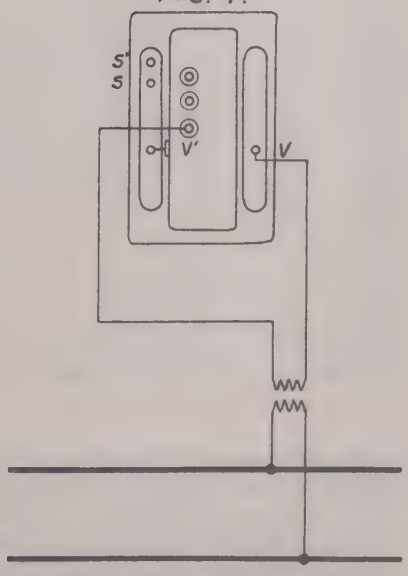
Direct Current
With Multiplier.

Fig. 3.



Direct and Alternating
Current.

Fig. 4.



Alternating Current
With Potential Transformer.

Voltage Terminal - or V is common for all ranges, and marking on other Terminals indicates the range for those Terminals.
Meters with Synchronous Clock- Connect Clock Supply to Terminals S and S'.

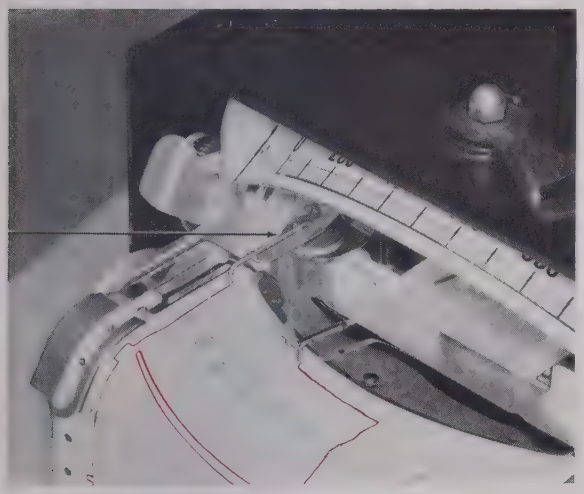
No. D-940

July 30, 1935.

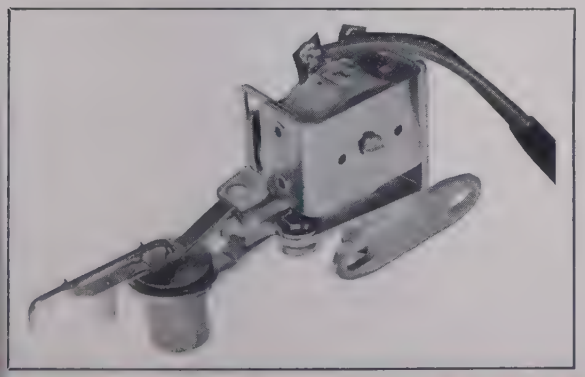
Chronograph Pens (Event Markers)

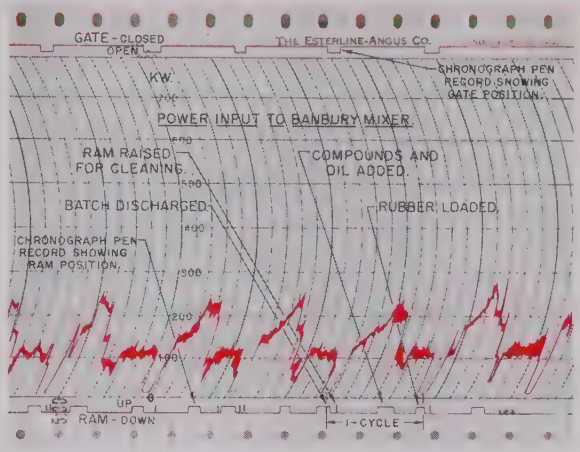
For Esterline-Angus Recorders

A chronograph pen is an electromagnetically operated pen that can be mounted to record in the margin of an AW recorder chart. It is highly useful for keying some event to the main record. For example, if a voltage record were being made of a feeder line, a chronograph pen could answer questions about a particular motor on the line: *when* did it begin running, *how long* did it run, and *how many times* did it start and stop during a particular period? Also, chronograph pens actuated simultaneously on several charts provide common reference points.



The picture above shows a chronograph pen positioned to record in the left-hand margin of a chart. Another such pen can be mounted to record in the right-hand margin. The electromagnet-pen assembly is shown in the picture below. The pen moves about 1/10 inch toward the edge of the chart when voltage is applied and it returns to the normal "off" position when voltage is interrupted. The pen assembly can follow ten complete on-off cycles in one second. The electromagnet can be furnished to accommodate any of the standard voltages listed in the accompanying table, or any special intermediate voltage which falls in the ranges 2-250 V DC or 6-240 V, 50-60 cycles.





The typical chart above shows power input to the driving motor of a Banbury mixer used to blend ingredients used in making rubber. Chronograph pens have been used to show operation of the gate and ram on the mixer. The ram forces the material against the rolls; the gate opens to permit a batch of rubber to be dumped. The time from the closing of the gate to the next opening is mixing time. Uniformity of mixing cycles can be also seen immediately by looking at the record of the pen monitoring the gate.

Electromagnet Specifications

Rated Voltage*	Coil Style	Milli-amperes	Watts per Circuit	Ohms per Coil (DC)	Ohms in Series With Coil
Direct Current					
2 Volts	N	570	1.1	3.5	None
4 Volts	K	286	1.1	14	None
6 Volts	J	231	1.4	26	None
8 Volts	G	131	1.0	61	None
10 Volts	F	99	1.0	101	None
12 Volts	F	119	1.4	101	None
14 Volts	E	90	1.3	156	None
16 Volts	D	67	1.1	238	None
18 Volts	D	76	1.4	238	None
24 Volts	C	65	1.6	372	None
28 Volts	B	42	1.2	666	None
32 Volts	A	29	0.9	1092	None
48 Volts	T	29	1.4	1650	None
125 Volts	B	41	5.2	666	2400
250 Volts	T	26	6.5	1650	8000
50-60 Cycles AC					
6 Volts	N	447	1.6	3.5	None
12 Volts	K	233	1.7	14	None
24 Volts	G	103	1.5	61	None
120 Volts	T	20	1.5	1650	None
240 Volts	T	21	4.5	1650	7000

*All electromagnets are guaranteed to operate at voltages 15% above or below rating.

Although it is preferable to install chronograph pens when the instrument is built, they can be added with little difficulty to Model AW recorders already in service. Complete installation instructions are furnished with each pen assembly. ***When ordering***, specify right or left-hand pen, voltage, frequency and, if for field installation, the instrument serial number.

THE ESTERLINE-ANGUS COMPANY

Box 596, INDIANAPOLIS 6, INDIANA

THE GRAPHIC

THE ESTERLINE-ANGUS CO., INC. • INDIANAPOLIS • *BULLETIN NUMBER 856*

HOW TO MAKE

Plant Surveys

WITH GRAPHIC INSTRUMENTS

Cost reductions, like gold, are where you find them. There is no easier way to locate wasteful operations than by making systematic surveys with electrical recording instruments

Fig. 1—Almost any plant, regardless of size, can profit from continuous plant surveys. Power waste shown up by the graphic records is often sufficient to pay for the survey equipment in only a few days of use. However, the records also show time of starting and quitting work, idle and productive time, handling and condition of equipment which frequently outweigh in importance the power savings

MAKING YOUR PRODUCT with more efficient use of labor, in less time, and getting more completed units per shift, are just as important as buying raw materials at the most advantageous price. So also, more efficient operation of every motor, machine, department and unit of a whole plant can contribute handsomely to the total profit.

Anyone who is familiar with plant operation knows how the electrical load is inclined to grow. Overmotored machines are installed. Jobs change on older machines so their drives no longer operate at maximum efficiency. Even a machine doing the same job month after month can deteriorate or the operator can become lax in his handling of it. Voltage decreases in certain parts of the plant; machines cannot produce as they should; fuses blow and motors burn out.

Continuous plant surveys are the way to avoid these pitfalls. Many of our customers keep their graphic instruments in use constantly on a systematic survey of every load from the total plant load, through each department down to each individual motor.

Records are filed for each load and successive records are compared with the previous ones. Any changes in character and magnitude of the load must be explained. Motors are shifted from one machine to another to keep each motor operating as near full load as possible. Defective equipment that wastes power is located and repaired before a breakdown causes a loss of production. Mishandling of equipment is readily revealed and operators are reinstructed so that *each machine produces the maximum number of pieces in the minimum time with the lowest power consumption.* Then each production unit in the plant is contributing its share to the total profit.

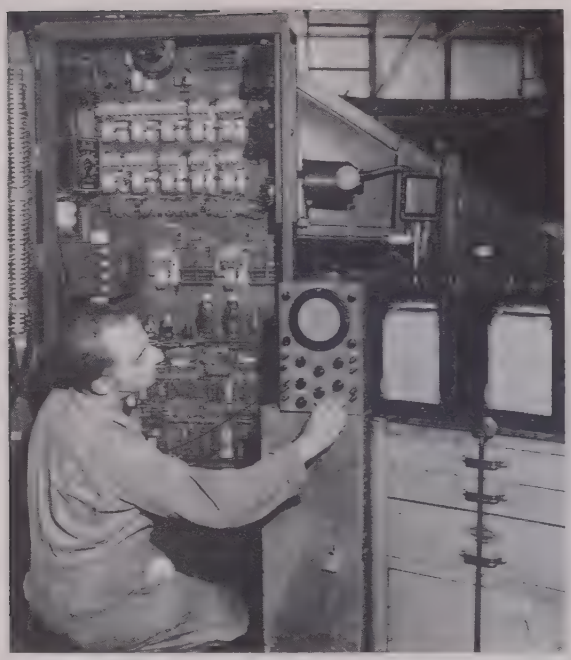


Fig. 2—Making a periodic analysis of a 500 Kva welder control panel with a graphic ammeter and voltmeter and an oscilloscope. This equipment welds 420 auto wheel spiders and rims per hour. (Courtesy Norris-Thermador Corp., Los Angeles, Calif.)

Graphic Instruments for Survey Work

The instruments used for survey work are recording ammeters, voltmeters, wattmeters (with Kva-Kvar phase shifting transformer) and power factor recorders. The number of each depends entirely on the size of the job to be done and the length of time allotted for the survey. The most useful single instrument is the recording wattmeter and a start at the job of a plant survey can be made with only this instrument.

A more complete set of equipment might include the following:

AC	DC	AC and DC
Voltmeter, 150/300/600 volts	Voltmeter 150/300/600 volts	AC-DC (Utility) Voltmeter or Rectifier Type
Ammeter, 0-5/0-10 A.	Ammeter 0-50/0-100 MV	Rectifier Type with several AC and DC voltage and current ranges
Wattmeter, 100/200/500 V. 5 Amps	Wattmeter 100/200/500 V., 5 Amp. 100 MV	AC-DC (Utility) Wattmeter 100/200/500 V. 5 Amp. 100 MV
Power Factor 120/240/480 V. 5 Amperes or a Wattmeter with Kva-Kvar Transformer		

Model D, Portable Universal Current Transformers
10/25/50/100/200/400/800:5 amperes
Annis Portable Split-Core Current Transformers
250/500/1000:5 amperes
1000/2000/3000:5 amperes

Shunts—Ammeter
5, 25, 100, 500, 1000, 3000 amperes
Shunts—Wattmeter
25, 100, 500, 1000, 3000 amperes.
If DC service is 3-wire, two wattmeter shunts of each size are required.
Kva-Kvar Portable Phase Shifting Transformer
Double Potential Transformer (Portable)
High-Voltage Portable Potential Transformers
2400/4800:120 volts
Control Transformers (if electric chart drives are used in meters)
240/480:120 volts
Complete sets 250 and 600 volt Quick Connectors
Chart Drive Couplings for synchronizing charts
Phase Rotation Indicator
Clamp-on Type Indicating Ammeter
Chart Inspector

Ammeters and Voltmeters

Where it is desired to record all three phase voltages and currents at one time, three voltmeters and three ammeters will be needed. Current and voltage ranges can be combined in the rectifier type recorder. If the plant also has DC service, rectifier type recorders are even more useful, since DC ranges can be provided as well as AC on these instruments. Identical meters can be purchased and then used either as ammeters or voltmeters on either AC or DC. Greatest flexibility of use per dollar of investment is provided.

Wattmeters

The type of service in the plant will dictate the kind of wattmeter to use. For single-phase and 3-phase, 3-wire circuits, the 2-current element AC wattmeter is sufficient. It can also be used on 3-phase, 4-wire but three current transformers are required with their secondaries connected in delta. This usually rules out the use of current transformers that are already installed. The 3-current-element wattmeter should be selected where any appreciable amount of

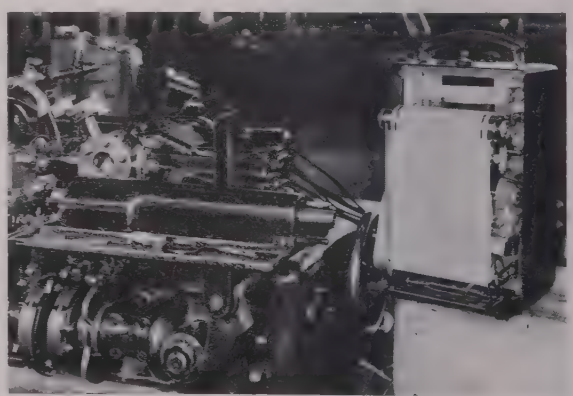


Fig. 3—A graphic wattmeter is an ideal tool for time study. Setting-up and cutting time as well as power required are shown. The minimum time for each step with the minimum power consumption represents maximum production and lowest cost per piece

3-phase, 4-wire service exists, or there is a probability that the plant distribution system will be changed to 3-phase, 4-wire to provide additional capacity. The 3-current element meter can be used on single phase

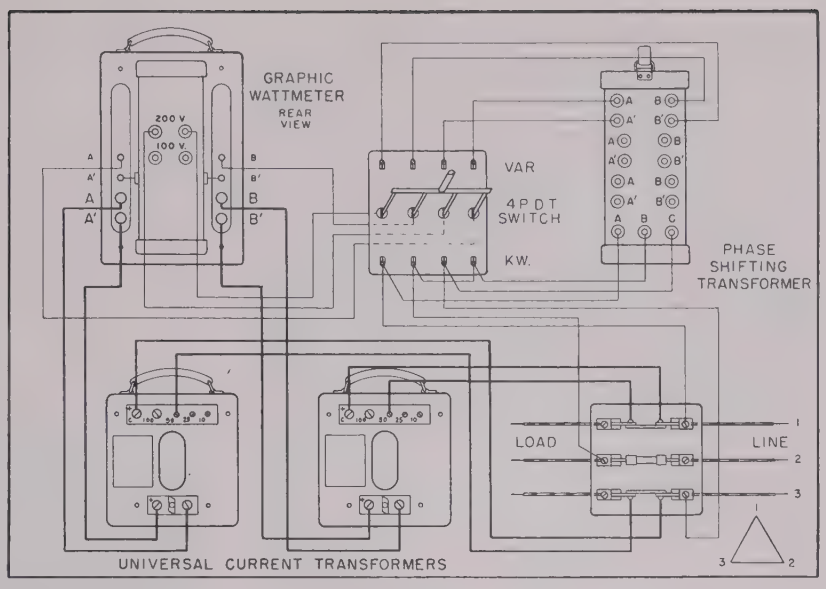


Fig. 4—Two wattmeters and a Kva-Kvar phase shifting transformer make it possible to record Kw and Kva or Kw and Kvar on unbalanced as well as balanced 3-phase circuits. The 4-pole double throw switch can be motor driven, if desired. Connections are shown using Quick Connectors (Fig. 15). Since fuses have been removed from two phases, it is desirable to connect another fuse block in series and replace the fuses, so adequate protection is provided at all times

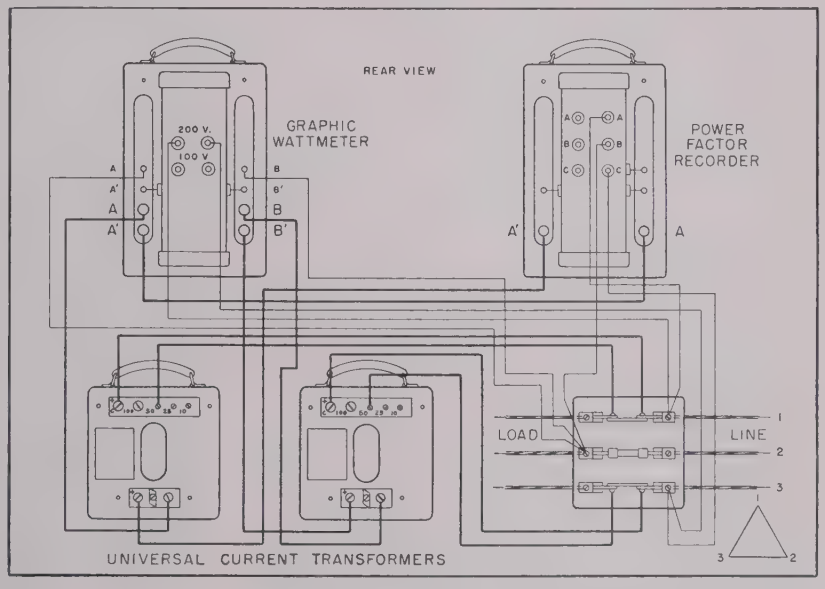


Fig. 5—A wattmeter and a power factor recorder give all the needed data about motor loads or two wattmeters and a Kva-Kvar transformer can be used (as in Fig. 4) and the power factor calculated. Here again it is desirable to connect a separate fuse block in series so all three phases are fused during the time records are being made

and on 3-phase, 3-wire circuits, where necessary, by following special connection diagrams.

For the utmost flexibility, the 4-current element wattmeter should be used. It can be connected as either a 2- or a 3-current element meter. It will also measure 3-phase, 4-wire delta combined light and power service. For plant survey work, it has the added advantage that it can handle heavier loads than the other wattmeters without current transformers.

If the plant has DC circuits, at least one of the wattmeters should be the AC-DC (Utility) type.

Power Factor Measurement

Studies of power factor are of value in that they can be used to show the extent of correction necessary to create a desirable power factor condition in the entire plant, or on each individual circuit. One method of measuring power factor employs a power factor recorder. This instrument is relatively simple to install, and has the advantage over other methods in that it reads power factor directly, without calculation. Caution must be exercised in its use on polyphase circuits, however, as it is accurate only on *balanced* loads such as polyphase motors.

Another method uses a wattmeter for measuring the power input, and a second wattmeter with a phase shifting transformer to read Kva or Kvar. The two records, Kw and Kva, or Kw and Kvar, give all the needed information about each motor, feeder or transformer bank, and the ratio of true power to apparent power can be calculated. See catalog section 35 for details. The method is accurate for any degree of

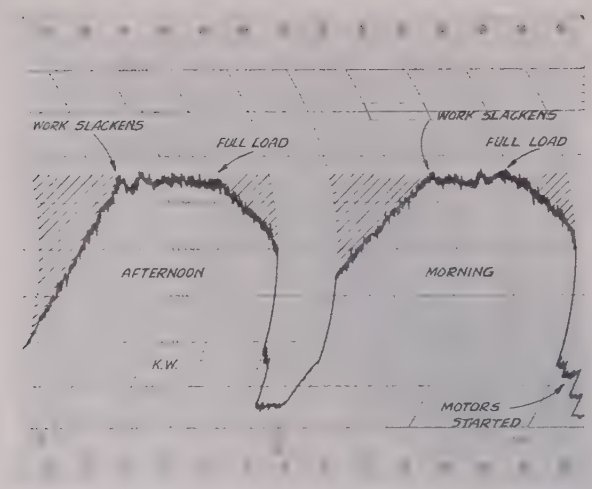


Fig. 6—An all-day graphic wattmeter record in a factory showing time lost starting work and anticipating quitting time. Constant watchfulness and the means of measurement are necessary to prevent this condition from developing in any plant

current unbalance, and is suitable for both 3-phase, 3-wire and 3-phase, 4-wire. Many users are convinced that this is the way to make all their studies on polyphase circuits. Since both recorders can be used as wattmeters, while the power factor recorder is a single purpose instrument, the Kw-Kva or Kw-Kvar combination makes better use of the money invested in meters. In general, the measurement of Kw and Kvar is recommended as it is less involved than the measurement of Kw and Kva, and the end results are the same. Also the Kvar record shows directly the corrective capacity required to improve the power factor on any circuit.

Accessories

Various current and potential transformers have been suggested in the list on page 2. The ratings of these devices will depend on the loads to be handled, voltages encountered in the plant, etc. Wherever current and potential transformers are already installed, they should be used in the survey, to eliminate the time required to connect another set into the circuit. Many plants have current and potential transformers installed for circuits above 1000 amps. and 480 volts.

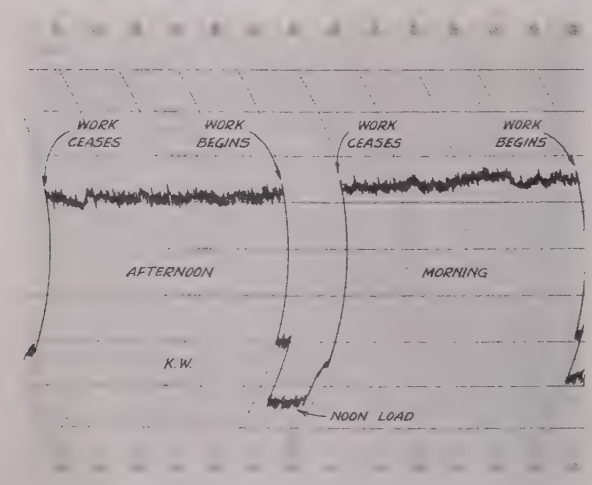


Fig. 7—After a thorough survey, the load record, in the same plant as Fig. 6, looked like this. Management, after being alerted, is continually watching to see that labor is productive

Studying the Total Load

As a complete study is made, attention will be focused on various loads where it will pay to have continuous graphic records made by permanently installed meters. The total plant load is one of these. The information available to the management from the total load record is far more than just kilowatts plotted against time. Here are the questions that can be answered by the total load records of volts, amperes, kilowatts and power factor:

Fig. 8—Permanent installation of graphic instruments is a necessity on such mills as this. The records provide the engineers the best means of studying mill operation. In many cases, the recorders pay for themselves by showing whether equipment failure was a result of mishandling by the operators or a defect in the equipment

1—What is the maximum plant load in kilowatts and amperes?
2—On what day of the week did it occur?
3—Was the peak load the same for each day?
4—If not the same, why not?
5—What was the load during noon hours?
6—Was it the same each day; if not, why not?
7—What is the night load?
8—Was the night load the same each night?
9—Is there evidence of waste of power by starting equipment before hours in the morning or letting it run after the plant is supposed to shut down?
10—How does the peak load compare with the power company's demand charge for the previous month?
11—How long did it take the plant to reach full power load after starting time in the morning and afternoon?
12—Is there evidence of a tendency to anticipate quitting time at noon and in the evening?
13—What is the maximum and minimum power factor of the load?
14—When did minimum power factor occur, and how do you account for it?

15—How does the power factor compare with that on which the power bill is based?
16—What is the maximum and minimum lighting voltage at the main bus?
17—When do maximum and minimum lighting voltages occur?
18—What is the maximum and minimum power voltage of the main bus?
19—When do maximum and minimum power voltages occur?
20—What is the voltage drop between the bus and the lamps at different points in the plant? (From previous survey records)
21—What is the voltage drop between the main power bus and the different motors in the plant?
22—How does the voltage at the lamps compare with the voltage rating of the lamps used?

Fig. 9—Sometimes faulty flow of materials causes a lapse in production. Without the steel in constant supply this battery of presses can't make auto body tops. Whether a curve like Fig. 6 is due to lack of material or to boondoggling, it still costs money and needs correction

Checking Up the Departments

The next step is to secure records on the different divisions or departments of the plant, thus enabling the engineer to localize some of the causes of undesirable conditions that may be shown by the load curve of the plant as a whole.

For example, if the record of total power shows that productive effort lags in the mornings and afternoon, or that quitting time is anticipated by workmen, the next step is to find in what departments this occurs. One of the advantages of graphic instruments is that this information can be obtained by placing the meters in the circuit at some remote point, and the exact conditions will be recorded.

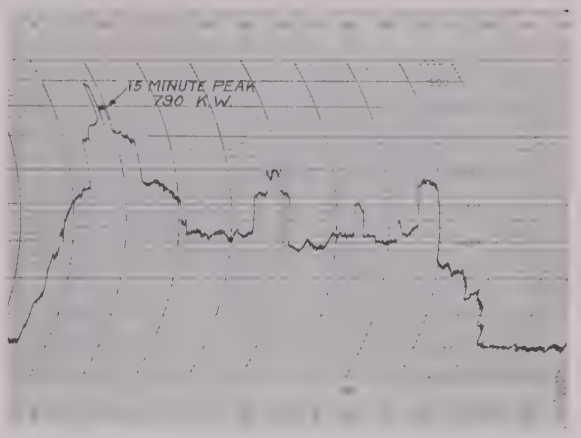


Fig. 10—This late afternoon peak was caused by lighting load being added to the power load on a dark day. It caused a new, higher demand peak for the entire month. Temporarily shutting off some equipment pays in such a situation

Where group drives are used, it is a good practice to check the friction load of each division of the plant at regular intervals. This testing must be done when the machines are not in productive use. Surprising results are often obtained.

In most instances a single day's run is sufficient for a departmental test, although things may be disclosed which will make advisable several days' run in order to see if such conditions repeat themselves. In most plants engineers use graphic voltmeters and wattmeters on feeders, and in many industries the information gained from such records has been of such value as to result in the installation of graphic instruments permanently in the power feeders to each department. Following is the information which usually can be obtained from the graphic records of the department:

1—Did the department start on time in the morning and at noon?
2—How long did it take for the department to reach full power load in the morning? How long after lunch?
3—To what extent was quitting time anticipated at noon and in the evening?

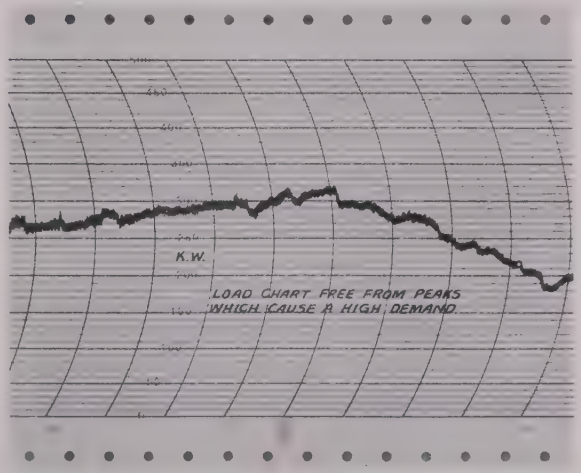


Fig. 11—This load chart is particularly free from short peak load that can establish an unnecessarily high demand charge. Only continuous plant surveys will keep it this way

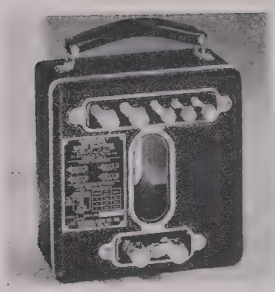


Fig. 12—The 7-range, Model D Universal current transformer is intended for plant survey work. It has ample capacity to operate one or more graphics, as shown in Figs. 4 and 5

Fig. 13—The portable split-core current transformer is useful where the circuit cannot be opened to insert a closed-core current transformer

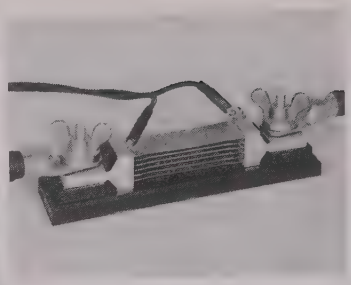


Fig. 14—On DC circuits where the load current exceeds the capacity of the meter, shunts must be used. Wattmeter shunts are 100 MV. Recording ammeters can be used with either 50 or 100 MV shunts

Fig. 15—Quick connectors facilitate making connections at a switch or fuse block

Fig. 16—The Kva-Kvar phase shifting transformer makes a wattmeter read Kva or Kvar. Model A with three sets of taps is shown. Another model with 4 sets of taps is available as well as a Model B transformer for Kvar measurement only

4—What is the friction load in the department?

5—Has the department a peak which corresponds with the total peak, and if so, what causes it?

6—Is there evidence of pyramiding of loads that cause pulsating peaks to occur?

7—What is the night load? The noon load?

8—Is there anything in the record which gives a clue to waste of power or of employee time?

9—What portion of the demand charge and energy consumption should be allocated to this department?

10—What is the power factor?

11—If the power factor is low are there any large induction motors that could be replaced by synchronous motors?

Charting Individual Motors

When the records of total load and of the departments have been obtained, the next step is to test each individual unit in the plant. The records of total load and those of the departments give a general overall measure of conditions, while the tests of individual units, show what each piece of equipment is contributing to the total result. Correction of any faulty condition shown by the overall record can best be done by carrying the test on to the different units, as it is these which show where the remedy must be applied.

On small units, say 50 horsepower and under, most engineers use only a graphic voltmeter and wattmeter, but on units larger than this it is customary to employ an ammeter and a power factor meter in addition. In making records on individual machines the engineer should see to it that conditions are normal, and he should be on the lookout for information which may affect any one or all of the different elements of cost, and in many cases the quality of the product as well. Many engineers in making such tests for information on power conditions have discovered other facts, bearing on labor losses, processing, condition of equipment, etc., which were of equal if not greater importance than the data they were actually seeking.

Such tests as we have described are especially illuminating in showing the performance of automatically operated equipment, such as pumps, air compressors and fans which are motor driven and automatically started and stopped. The record shows when and how long each piece of equipment was operated, and how long it was idle each day. It discloses waste if the automatic equipment is not functioning properly.

The length of time instruments should remain in the circuit of an individual machine depends altogether upon conditions. In some cases a 24-hour run is necessary; in others, a full working day, and in still others a much shorter time will suffice. With many types of load it is better to use a slower chart speed and a longer time in order to cover all conditions, and in other cases a shorter time with rapid chart speeds is a better procedure. In many instances, for example, where the motor is driving a group of machines or a line of shafting, it is well to have a portion of the record show the idle or friction load in order to discover any unusual conditions that have developed since the last survey.

The records taken in the survey of individual machines

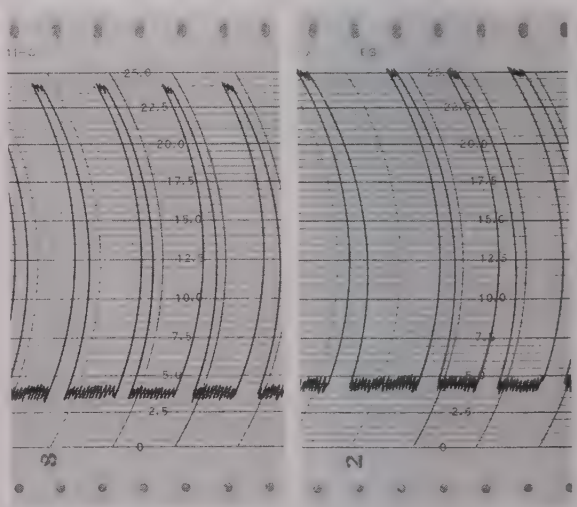


Fig. 17—At the right is the record made on a 60 HP, 440-volt, 3-phase 60 cycle motor driving an air compressor. The motor was replaced by one of 30 HP and the record at the left obtained. The wattmeter chart speed was 3 inches per minute in both cases

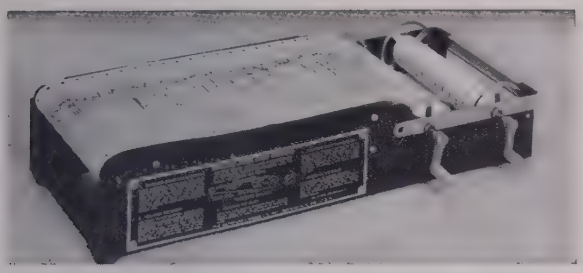


Fig. 18—The chart inspection box is a convenient accessory for inspecting records and making notes on them

should be studied and answers obtained to such questions as the following:

1—If the unit is a motor, what is its rating?
2—What is the maximum, minimum and average load on the motor?
3—What is the power factor?
4—If the motor is not the correct size, what is the horsepower of the motor that should replace it?
5—Is the voltage at the motor terminals the proper value?
6—How many Kw does the unit contribute to the peak load?
7—What will be the Kw load and power factor of this drive after the correct size of motor is installed?
8—Is this a unit which could be operated on "off peak" service to reduce the maximum demand?
9—Is the load on this unit one of those contributing to any loss of productive effort shown by the departmental record?
10—What is the idle or friction load of the unit?
11—Does the friction load show any marked increase since the last survey?
12—Does the record show any characteristics which indicate a faulty condition of the motor or the equipment which it drives?
13—Is the power getting all the way to the tool or is a large part of it lost?
14—Does the record show any unnecessary loss of time on the part of the operator of the equipment?

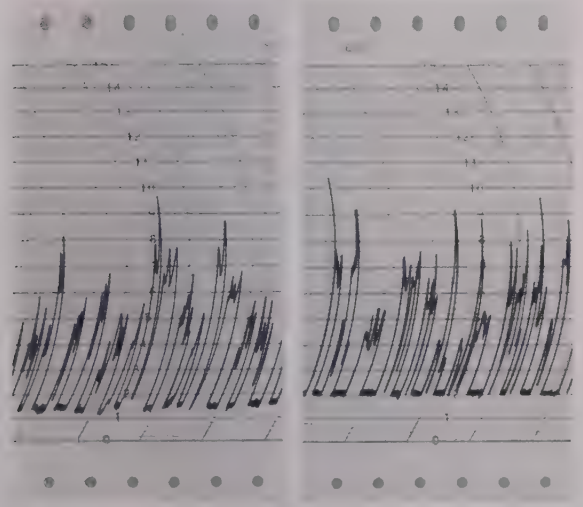


Fig. 19—Record at the right was made on a 25 HP, 1200 RPM, 440-volt, 60 cycle, 3-phase motor driving a disc grinder. Since the inertia of the disc helps carry peak loads, this motor was replaced by one of 10 HP which made the record at the left. Chart speed is 6 inches per hour

Fig. 20—For general survey work a portable wattmeter should have 100, 200 and 500 volt potential taps. AC ammeters should have ranges of 0-5/10 amperes; DC ammeters 0-50/100 MV; and voltmeters will be most useful with ranges of 0-150/300/600 volts

15—Was the loss of time shown on the record due to faulty flow of work to the machine, rather than laxity on the part of the operator?
16—How does the character of this record compare with others taken on similar equipment in the plant?
17—Does the record disclose any important information regarding operations or processes, which is of value in reducing cost or maintaining the quality of the product?
18—Does the record show that the operator is handling the machine in accordance with the job specifications for this particular operation?

Using the Information

Obviously the information obtained in a complete plant survey touches the interests of several departments of a modern industrial plant. Purchase or generation of power, maintenance, cost determination, engineering, production and inspection are all at times covered in the records obtained.

We know that in some plants the survey is made by one department, usually either maintenance or engineering, and then the records with proper interpretations are made available to other departments through the medium of an efficiency committee representing all departments. A systematic study of plant operation usually discloses some faults, shortcomings and oversights of men, and it is quite important to have a system set up which can obtain the results and make use of them without creating friction.

Report to Executives

The most far-reaching results are being obtained in those plants where a complete report of each survey, with the proper explanation, summary and con-

clusions, is placed in the hands of the management. The department making the survey reports its findings to the efficiency committee. This group considers each cause of inefficiency and waste and makes recommendations to the management for the solution of each problem. From an executive, the head of each department touched by the report, then receives the decisions or instructions of the management and uses the report as a basis for carrying out the instructions.

Contents of the Report

Considerable effort is involved in making a plant survey and the report must be carefully written to insure the utmost use of the results. The report should contain:

1—A general description of the existing electrical system. Some engineers include a one-line diagram of the system. Others prefer to show a diagram of the service and main feeders at the beginning of the report. Then as each departmental load is discussed, a diagram of the electrical system in that department is included.

2—A description of the mechanics of the survey.

3—Tables of recorded and calculated data, and prints of the graphic meter charts. All charts should be marked at the points where they show information discussed in the report. This is essential to clarity and ease of digesting the report as the management is usually not as experienced as the engineer in reading charts.

4—The salient points in each record should be called to the reader's attention, such as late starting, early quitting, high idle loads, low voltage, poor power factor, etc.

(a) Discuss recommendations for correcting each faulty condition with an estimate of the cost of correction and the saving to be made.

5—Summarize the recommendations for the benefit of the busy executive.

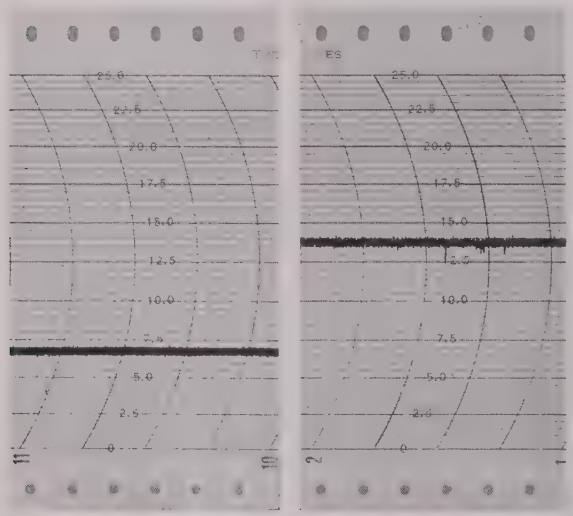


Fig. 21—A 10 HP, 440-volt, 3-phase, 60 cycle, 1200 RPM motor driving an exhaust fan was overheating. There was a 10 inch pulley on the motor and a 12 inch pulley on the fan (record at right). The motor pulley was changed to 8 inch and it was found that a 7½ HP motor would carry the load (left) and provide ample air circulation

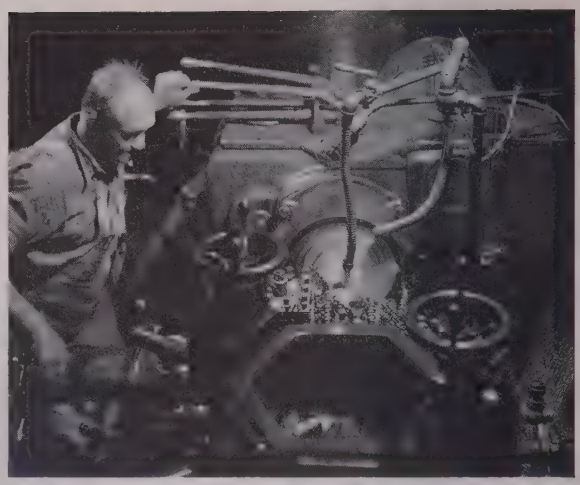


Fig. 22—Periodic tests on individual machine show whether it is being properly maintained, condition of the tools and handling by the operator

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Typical examples of the kind of problems solved by a plant survey are shown in the following bulletins which can be had for the asking:

236-A—$235,000 a Year Saved with Graphic Meters
537-A—$10,000 a Year Saved
934 —Power, Power Factor and Profits
1036 —Engineering a Steel and Wire Plant With Graphic Instruments

For specific technical information on graphic instruments for plant survey work ask for:

Catalog Section or Bulletin
30—AC Ammeters and Voltmeters
33—Wattmeters
35—Kva and Kvar
37—Power Factor
40—DC Ammeters and Voltmeters
42—DC Milliammeters
46—Tachometers
48—Rectifier Recorders
155-A—Model D Universal Current Transformers
255-A—Annis Split-Core Current Transformers
80—Accessories and Attachments
Current Transformers
Phase Shifting Transformers
Double Potential Transformers
90—Charts and Writing System Supplies

The product representative near you can help you plan your survey and the graphic instruments you need. Contacting him or the factory does not obligate you in any way

THE ESTERLINE-ANGUS COMPANY, INC.

Pioneers in the Manufacture of Graphic Instruments

P. O. BOX 596, INDIANAPOLIS 6, INDIANA

Bulletin No. 856
Printed in U. S. A., 60M

Product Representatives in Most Principal Cities

CHARTS

and

Writing System Supplies

for all models of

ESTERLINE-ANGUS Graphic Instruments

The finest recorders, with the most accurate measuring elements and precision chart drives are rendered useless unless the vital combination of charts, ink and writing system is equally well engineered. Each manufacturer has worked out by diligent research the combination that works best in its particular recorder. Best performance results from using E-A charts, ink and writing system supplies in E-A recorders.

THE ESTERLINE-ANGUS COMPANY

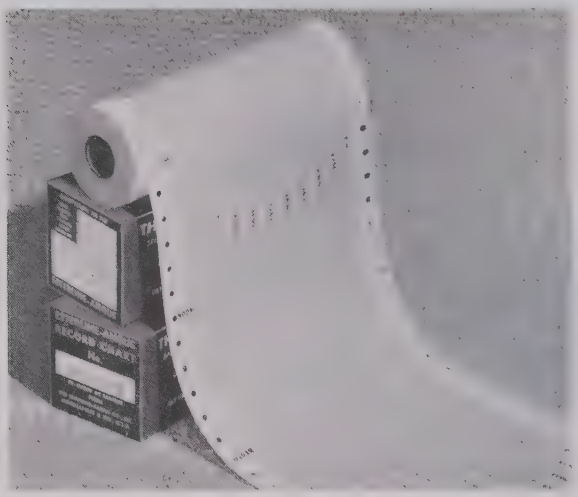
"The Meter With a Record" for Over 50 Years

P. O. BOX 596, INDIANAPOLIS 6, INDIANA

Catalog Section 90

(February 1960)

Charts for E-A Recorders



Charts are individually boxed. Packed for shipment each chart weighs about 0.6 lb.

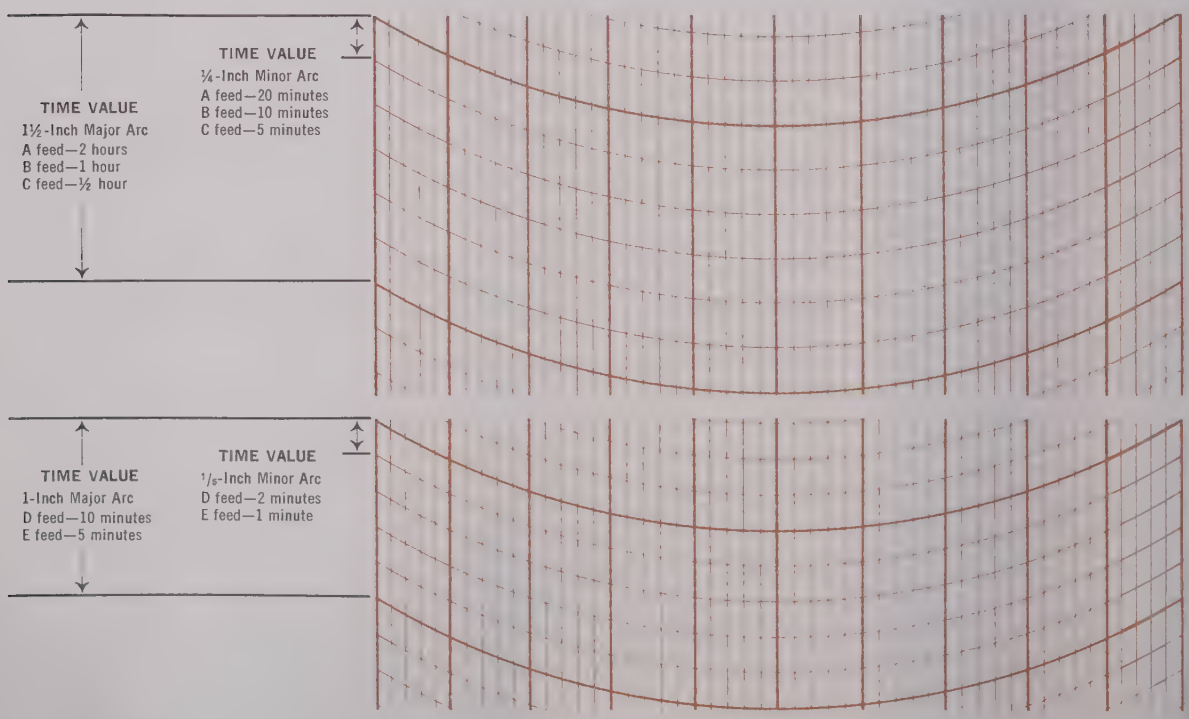
E-A record charts are of a special grade of paper, manufactured to exacting specifications, having the desired ink-absorbing qualities and the minimum change of dimensions with changes in humidity. The paper is wound on a high quality, accurately dimensioned core, which is important for proper chart feeding. The chart, ink, writing system and chart drives are parts of the composite recorder, all engineered as a major unit. To insure accuracy and continuity of records, use only E-A charts and ink in E-A recorders.

All standard charts are printed in two colors of special ink which does not interfere with the record being drawn by the recorder pen. Longitudinal rulings and arc or cross lines are in brown ink, with all other printing, such as range numbers and time numbers, in contrasting blue. The time values of the two standard arc spacings are illustrated below.

Special equipment has been designed and built for the production of charts. The paper is manufactured in quantity, shipped to our plant and thoroughly seasoned before it is printed. The chart with its record can be preserved for years, without appreciable deterioration.

Dimensions

All charts are 6 inches wide and have perforations along each edge at ½-inch intervals. The ruled portion of standard charts extends over a width of 4½ inches. Each chart is 103 feet long, the useful length being 100 feet; three feet are allowed for threading up the recorder. Range numbers are printed across the chart every 9 inches, and the time numbers along the left-hand margin at intervals of 3 or 6 inches.



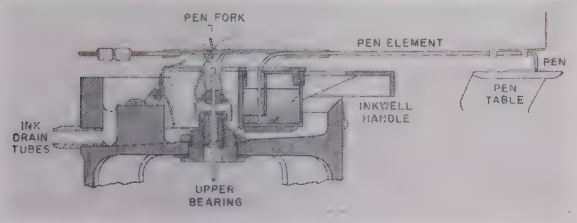
The E-A Direct-Writing Mechanism

Esterline-Angus pioneered the direct-writing system for graphic instruments. A mechanism in which the pen is operated directly by the measuring element has many distinct advantages. The E-A direct-writing system consists of two simple, removable parts: a refillable inkwell, and a pen element carried in a fork mounted on the staff of the measuring element.

The pen element and inkwell can be inserted and removed without the use of tools or danger of disturbing any accurately aligned parts. Complete access to the writing system is provided, without tilting or swinging the chart drive out of the way.

The Inkwell

The inkwell is held securely in place in the cavity in the measuring element top assembly. The body and cover are made of a high-grade resilient plastic material. The cover is removable for cleaning. The opening in the cover is surrounded by a baffle which extends almost to the bottom of the inkwell. The cover opening is large enough to permit free movement of the pen element, yet is small enough to minimize evaporation.



Cross-sectioned view of the measuring element top shows the inkwell and pen element in place, drain tubes that prevent spilled ink from reaching any current-carrying parts, as well as the canopy shielding the upper bearing

The Pen Element

The silver pen tube is fitted with knife-edges which rest in the pen fork carried by the armature staff. One end of the pen tube dips into the inkwell through the narrow cover opening. Ink flows through the tube by capillary action to the pen point at the other end of the pen tube. The pen point is finished with a fine smooth tip, to draw a narrow uniform line on the record chart. The pen element is easily lifted out without the use of tools. Adjustable weights on the pen element permit balancing as described in the instruction book accompanying each instrument.

Ink

The manufacture of a superior ink for direct-writing recorders is not a simple problem, because the requirements are so conflicting. The ink must not evaporate readily in the inkwell, yet the inked record on the chart paper must dry quickly. It must not leave an insoluble residue in the inkwell which will clog the pen and it must not be corrosive to the pen tube.

Continuous research and control of the manufacturing process enable E-A ink to meet these stringent requirements. It is supplied in two colors, red or green, which can be mixed to form a third color.

Ordering Charts

Each different range, ruling and speed of chart is designated by a number composed of several figures and a letter (e.g. 1310-A, 43192-C). The figures indicate the ruling and range; the suffix letter designates the speed in *inches per hour* that the chart's time markings will accommodate. Therefore, ***charts should always be ordered by number, including the suffix letter.*** The table at right shows the letters corresponding to the most frequently used hourly chart speeds. The table also shows the minimum running time per chart for different chart speeds.

Charts with ¼ or ⅛ inch arc spacing can be furnished without time numbers, the suffix letters being "X" and "V" respectively. Such charts are used on intermittently-operated recorders or those running only at minute or second speeds.

If a permanently-installed recorder must have a

SUFFIX LETTER AND MINIMUM RUNNING TIME

Suffix Letter	Speed In. Per Hr.	Feet Used Per Day	Feet Used Per Week	Minimum Running Time in Days
A	¾	1½	10½	65⅔
B	1½	3	21	32⅔
C	3	6	42	15⅔
D	6	12	84	7⅓
E	12	24	168	3⅔

Speed Inches Per Min.	Feet Used Per Hour	Feet Used Per Day	Minimum Running Time in Hrs.
¾	3¾	90	26⅔
1½	7½	180	13⅓
3	15	360	6⅔
6	30	720	3⅓
12	60	1440	1⅔

At ¾, 1½ and 3 inches per second, one chart lasts 26⅔, 13⅓ and 6⅔ minutes respectively.

scale which does not correspond to a standard chart, usually a chart of some different range can be employed together with an appropriate multiplying factor. On portable meters and other meters having odd or multiple ranges, it is usually most convenient to use a chart with a range of 0-1 or 0-100 and then multiply the readings by a constant.

Stock Charts

The feeds of each chart carried in stock are shown opposite each chart listing in the following tables. Over 600 types of charts are in stock at our factory at all times, and most chart orders can be filled within two working days after receipt of order.

Special Charts

It is impractical to carry in stock every possible combination of ruling, range, and speed. Often, however, we can meet a customer's requirements by printing an unlisted, non-stocked chart for which tools are available. In such cases, a special set-up charge can be avoided if a quantity of 48 or more charts are ordered at regular price. Where this quantity is more than needed, we recommend substituting a suitable stock chart, obtainable without minimum quantity restrictions.

In some cases, a customer may require a special chart for which tools are not already available. We will tool for and print such a chart to customer specifications if it can be printed on our machinery. Among other restrictions, the chart must be six inches wide and have our standard perforations.

We will gladly make quotations for special tooling, or send samples of unlisted, non-stocked charts, upon receipt of complete details.

Blank 1000-X Charts

For special purposes, some users prefer a blank perforated chart having no printing in the recording area. Such paper is designated by the number 1000-X.

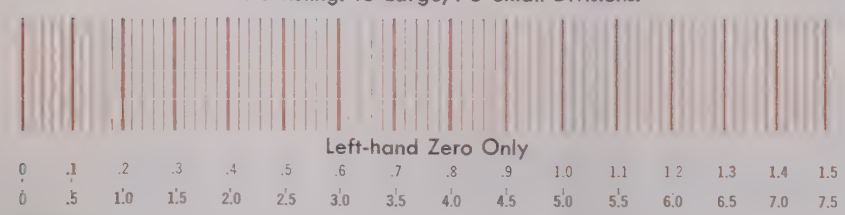
4300 SERIES

Charts for Model AW, LR, MS and EB DC Ammeters, DC Milliammeters, DC Microammeters, DC Voltmeters, Speed, Pressure, KVA, Rectifier AC-DC Ammeters and Voltmeters, and Model AW Wattmeters and KVAR Meters.

Uniform ruling along the arc. Ruled portion of charts shown actual size. Typical range numbers are illustrated for each ruling.

10-50 Ruling. 10 Large, 50 Small Divisions.

15-75 Ruling. 15 Large, 75 Small Divisions.



LEFT-HAND ZERO

Chart Number†	Chart Range	Ruling	Stock Feeds*
4300	No Range Nos.	10–50	A/B/C D E X
4302	No Range Nos.	15–75	A/B C D X
43022	No Range Nos.	18–90	D
4303	No Range Nos.	8–40	A B/C X
4304	No Range Nos.	12–60	C/D/E/X
4305	0–1	10–50	A/B/C/D/E V X
43052	0–1.5	15–75	A/B/C/X
4306	0–2	8–40	A/B/C/X
43061	0–2.5	10–50	C
43062	0–3	12–60	B/C
43065	0–4	8–40	C
4309	0–5	10–50	A/B/C/D/E/X
43091	0–6	12–60	A/C
43092	0–7.5	15–75	C
4310	0–10	10–50	A/B/C/D/E/X
43102	0–15	15–75	A/B/C/D/X
43105	0–20	8–40	A/B/C/D/E/X
4311	0–25	10–50	A/B/C/D/X
43112	0–30	12–60	A/B/C/D/X
43115	0–40	8–40	A/B/C/X
4312	0–50	10–50	A/B/C/D/E/X
43121	0–60	12–60	A/B/C/D/E/X
43122	0–75	15–75	A/B/C/D/E/X
43125	0–80	8–40	A/B/C
4313	0–100	10–50	A/B/C/D/E/X
43131	0–120	12–60	A/B/C/D/E/X

*If desired feed is not shown as Stock, order at least 48 to avoid set-up charge.

†Select the correct chart number, corresponding to the range numbers desired and ADD the proper speed designating letter. See page 3.

4300 Series, *Continued*

Chart Number†	Chart Range	Ruling	Stock Feeds*
43135	0–125	10–50	B/C
4314	0–150	15–75	A/B/C/D/E/X
43141	0–160	8–40	B/C
4315	0–200	8–40	A/B/C/D/E/X
4316	0–250	10–50	A/B/C/D/E/X
4317	0–300	12–60	A/B/C/D/E/X
4318	0–400	8–40	A/B/C/D/E/X
4319	0–500	10–50	A/B/C/D/E/X
43192	0–600	12–60	A/B/C/D/E/X
4320	0–750	15–75	A/B/C/X
43202	0–800	8–40	A/B/C/D/E/X
4321	0–1000	10–50	A/B/C/D/E/X
43212	0–1200	12–60	A/B/C/D/X
4322	0–1500	15–75	A/B/C/D/E/X
43222	0–1600	8–40	A/B/C/X
43225	0–1800	18–90	C/X
4323	0–2000	8–40	A/B/C/D/E/X
43231	0–2400	12–60	A/B/C
43232	0–2500	10–50	A/B/C/X
4324	0–3000	12–60	A/B/C/D/E/X
43242	0–4000	8–40	A/B/C/D/E/X
43245	0–4500	18–90	B/C
4325	0–5000	10–50	A/B/C/D/X
43252	0–6000	12–60	A/B/C/D/E
4326	0–7500	15–75	B/C
43262	0–8000	8–40	A/B/C
4327	0–10000	10–50	A/B/C/D/E/X
43272	0–12000	12–60	A/B/C
4328	0–15000	15–75	A/B/C/X
4329	0–20000	8–40	A/B/C
4330	0–25000	10–50	C
43302	0–30000	12–60	B/C

CENTER ZERO

43042	No Range Nos.	15–30	X
43311	0.5–0–0.5	10–50	C/X
43315	1–0–1	10–50	X
4362	2.5–0–2.5	10–50	A/C/X
4331	5–0–5	10–50	A/B/C/D/E/X
4332	10–0–10	10–50	A/B/C/D/E/X
43312	12–0–12	12–60	B/C
43321	15–0–15	12–60	A/C/X
43322	20–0–20	8–40	A/B/C/X
4361	25–0–25	10–50	A/C/D/E/X
4334	30–0–30	12–60	A/B/C/X
43342	40–0–40	8–40	A/B/C
4346	50–0–50	10–50	A/B/C/X
4347	60–0–60	12–60	A/B/C/X
4335	75–0–75	15–30	A/B/C
4363	80–0–80	8–40	A/B/C
43351	90–0–90	18–90	D
4333	100–0–100	10–50	A/B/C/D/X
43362	125–0–125	10–50	C/D
43352	150 0–150	12–60	A C/E X
4337	200–0–200	8–40	A C D
43331	250–0–250	10–50	C
4343	300–0–300	12–60	C
43432	400 0–400	8–40	C
4344	500 0 500	10–50	C
4340	600–0 600	12 60	C D
4336	750 0 750	15–30	C D
4341	800–0–800	8 40	C
4345	1000 0–1000	10–50	B C D E
43452	1500 0–1500	12–60	C
4350	2000 0–2000	8–40	B C
43502	2500 0 2500	10–50	C
43512	3000 0–3000	12–60	C D
4352	4000 0–4000	8–40	A B C
43521	5000 0 5000	10–50	A B C
43522	6000 0 6000	12–60	A C
4353	8000 0 8000	8 40	A C X
43332	10000 0 10000	10 50	B C

*Desired feed is not shown as Stock, order at least 48 to avoid rup charge.

8-40 Ruling. 8 Large, 40 Small Divisions.

Left-hand Zero

0	.25	.5	.75	1.0	1.25	1.5	1.75	2.0
0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
0	10	20	30	40	50	60	70	80
0	20	40	60	80	100	120	140	160

Center Zero

20	15	10	5	0	5	10	15	20
40	30	20	10	0	10	20	30	40
80	60	40	20	0	20	40	60	80

12-60 Ruling. 12 Large, 60 Small Divisions.

Left-hand Zero

0	.25	.5	.75	1.0	1.25	1.5	1.75	2.0	2.25	2.5	2.75	3.0
0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
0	10	20	30	40	50	60	70	80	90	100	110	120
0	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400

Center Zero

12	10	8	6	4	2	0	2	4	6	8	10	12
30	25	20	15	10	5	0	5	10	15	20	25	30
60	50	40	30	20	10	0	10	20	30	40	50	60
150	125	100	75	50	25	0	25	50	75	100	125	150

15-30 Ruling. 15 Large, 30 Small Divisions.

Center Zero Only

75	70	60	50	40	30	20	10	0	10	20	30	40	50	60	70	75

18-90 Ruling. 18 Large, 90 Small Divisions.

Left-hand Zero

0	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800

Center Zero

90	80	70	60	50	40	30	20	10	0	10	20	30	40	50	60	70	80	90

†Select the correct chart number, corresponding to the range numbers desired and ADD the proper speed designating letter. See page 3.

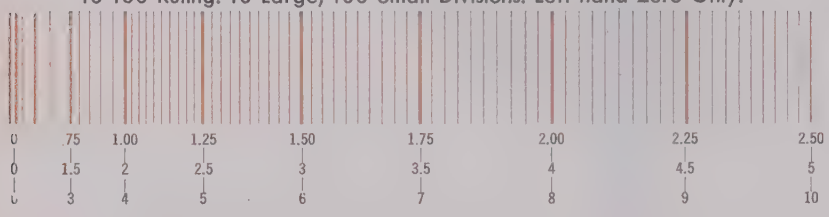
1300 SERIES

Charts for all Models of Dynamometer Type, AC Ammeters and AC and AC-DC (Utility) Voltmeters.

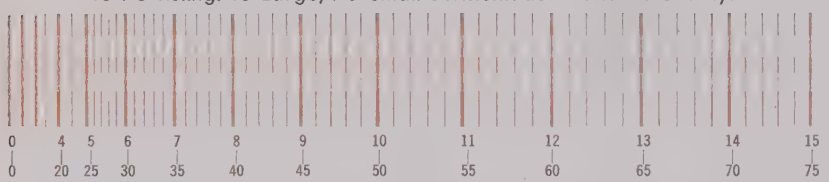
Approximately quadratic ruling. Ruled portion of charts shown actual size.

Due to the quadratic characteristics of these chart scales, it is not feasible to include in the extreme lefthand portions (below approximately 10-15% of the scale width) the full number of large and small division ruling lines. *Typical range numbers are illustrated for each ruling.*

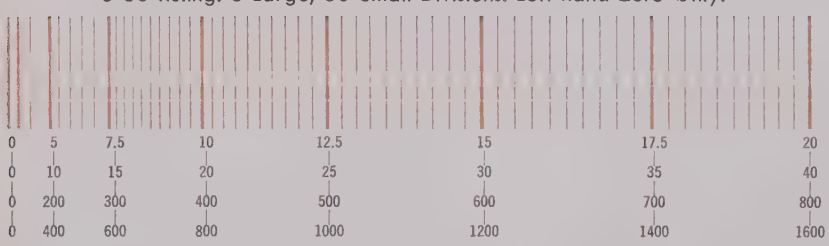
10-100 Ruling. 10 Large, 100 Small Divisions. Left-hand Zero Only.



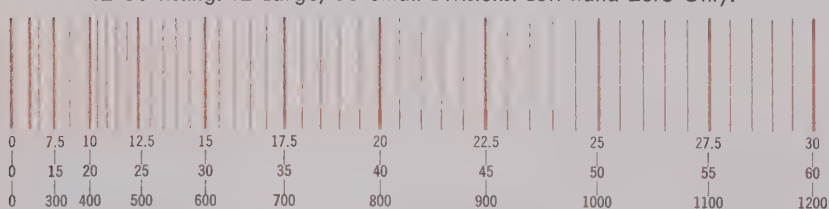
15-75 Ruling. 15 Large, 75 Small Divisions. Left-hand Zero Only.



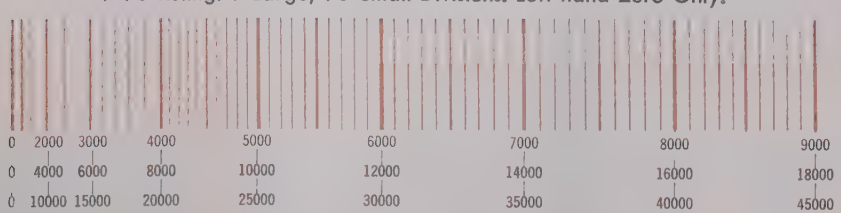
8-80 Ruling. 8 Large, 80 Small Divisions. Left-hand Zero Only.



12-60 Ruling. 12 Large, 60 Small Divisions. Left-hand Zero Only.



9-90 Ruling. 9 Large, 90 Small Divisions. Left-hand Zero Only.



LEFT-HAND ZERO

Chart Number†	Chart Range	Ruling	Stock Feeds*
1300	No Range Nos.	10-100	C X
1301	No Range Nos.	15- 75	
1302	No Range Nos.	8- 80	—
1303	No Range Nos.	12- 60	
1304	No Range Nos.	9- 90	
1307	0–2.5	10-100	C
1310	0–5	10-100	A/B/C/D E X
1311	0–10	10-100	A/B/C/D
1312	0–15	15- 75	B/C
13122	0–20	8- 80	C
1313	0–25	10-100	C
13132	0–30	12- 60	C
13135	0–40	8- 80	—
1314	0–50	10-100	A/B/C/D X
13141	0–60	12- 60	C
13142	0–75	15- 75	A/B/C/X
1315	0–100	10-100	A/B/C/D/E
1316	0–150	15- 75	A/B/C/D/E/X
1317	0–200	8- 80	A B/C E
1318	0–250	10-100	B/C
1319	0–300	12- 60	A/B/C/D/E/X
13192	0–400	8- 80	B/C
1320	0–500	10-100	B/C
13202	0–600	12- 60	A/B/C/X
1321	0–750	15- 75	B/C
1334	0–800	8- 80	C/X
1322	0–1000	10-100	C/X
13222	0–1200	12- 60	C
1323	0–1500	15- 75	C
13231	0–1600	8- 80	C
1324	0–2000	8- 80	A/B/C
13242	0–2500	10-100	—
1325	0–3000	12- 60	A/B/C
1326	0–4000	8- 80	C
1327	0–5000	10-100	B/C
13272	0–6000	12- 60	A/B/C
1328	0–7500	15- 75	C
1337	0–9000	9- 90	A/B/C
1329	0–10000	10-100	C
1330	0–15000	15- 75	A/B/C
13302	0–18000	9- 90	A/B/C
1331	0–20000	8- 80	B
1339	0–45000	9- 90	A/B/C
1333	0–50000	10-100	—
1341	0–90000	9- 90	A/B/C
1345	0–180000	9- 90	B

†Select the correct chart number, corresponding to the range numbers desired and ADD the proper speed designating letter. See Page 3.

*If desired feed is not shown as Stock, order at least 48 to avoid set-up charge.

1700 SERIES

Operation Recorders

Chart Number†	Pen Position Numbers	Stock Feeds*
1700	None	B/C/D/E/V/X
1705	1–5	A/B/C/D/E/X
1710	1–10	A/B/C/D/E/X
1720	1–20	A/B/C/D/E/V/X
1740	21–40	A/B/C/D/E/X
1760	41–60	A/B/C/D/X
1780	61–80	B/C/D/X
17100	81–100	C/X
17120	101–120	C/X
17140	121–140	——
17160	141–160	——
17180	161–180	——
17200	181–200	——

Chart Number†	Chart Range	Ruling	Stock Feeds*

1500 SERIES

Frequency

1515	55–65 cycles	10–50	A/B/C/D/X
1550	45–55 cycles	10–50	C/D
1520	20–30 cycles	10–50	B/C
1552§	45–65 cycles	10–40	C
15522§	46–66 cycles	10–40	B/C

1400 SERIES

Power Factor

1407	.50–1.00–.70	8–18	A/B/C
1403§	.40–1.00	6–13	C

1600 SERIES

Conductivity (Not Illustrated)

1600§	0–3000	15–30	B
1605§	0–infinity	18–61	A/B

2300 SERIES§

Used only for Model LR, MS and EB Var and Wattmeters. Not for Model W Meters. These rulings not illustrated.

LEFT-HAND ZERO

Chart Number†	Chart Range	Ruling	Stock Feeds*
2302	No Range Nos.	10–50	——
2310	0–1	10–50	A/B/C
23102	0–2	8–40	C
2312	0–5	10–50	C
2313	0–10	10–50	C
23142	0–20	8–40	C
2315	0–25	10–50	C
2318	0–100	10–50	B
23182	0–120	12–60	C
2319	0–150	15–30	A/C
2320	0–200	8–40	B/C

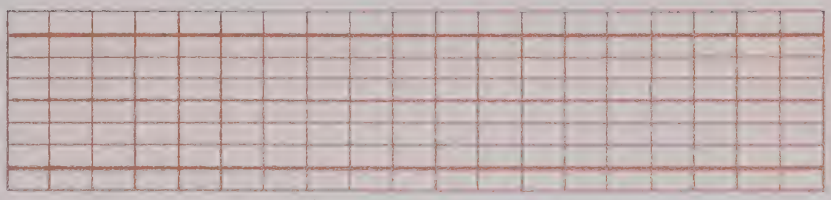
Chart Number†	Chart Range	Ruling	Stock Feeds*
2322	0–300	15–30	A/C
2323	0–400	8–40	A/B
23232	0–450	15–30	B
2324	0–500	10–50	B/C
23242	0–600	12–60	C
23252	0–800	8–40	B/C
2326	0–1000	10–50	B/C
23262	0–1200	12–60	B/C
2327	0–1500	15–30	B
23272	0–1600	8–40	A/C
2328	0–2000	8–40	C
23282	0–2400	12–60	C
2329	0–2500	10–50	C

Chart Number†	Chart Range	Ruling	Stock Feeds*
2330	0–3000	15–30	B/C
2331	0–4000	8–40	B/C
2332	0–5000	10–50	B/C
23322	0–6000	12–60	B/C
2333	0–7500	15–30	C
23332	0–8000	8–40	C
2334	0–10000	10–50	C
23342	0–12000	12–60	C
2335	0–15000	15–30	C

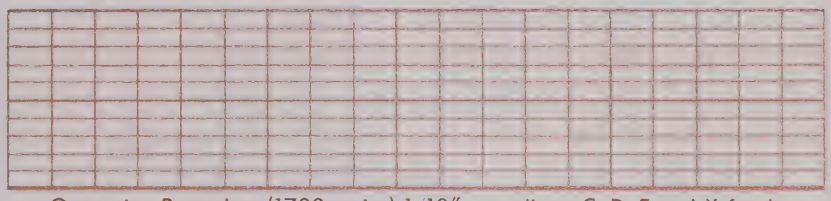
CENTER ZERO

2336	100–0–100	10–40	A/C
2346	1200–0–1200	10–40	C
23372	8000–0–8000	10–40	B

Ruled portion of charts shown actual size.

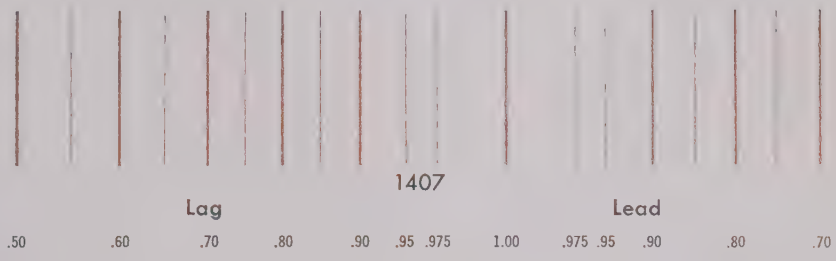


Operation Recorders (1700 series) 1/8″ cross lines, A, B and V feeds.

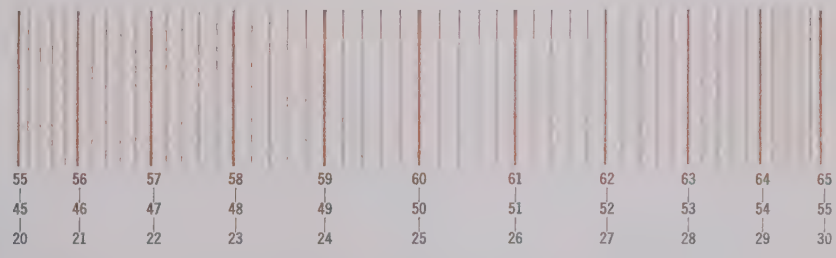


Operation Recorders (1700 series) 1/10″ cross lines, C, D, E and X feeds.

Power Factor Recorders (1400 series)



Frequency Recorders (1500 series) 10-50 Ruling. 10 Large, 50 Small Divisions.

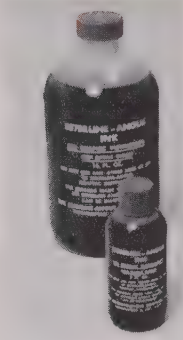


†Select the correct chart number, corresponding to the range numbers desired and ADD the proper speed designating letter See page 3.

*If desired feed is not shown as Stock, order at least 48 to avoid set-up charge.

§Not illustrated.

Writing System Parts and Supplies



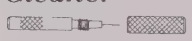
Ink

Recorder ink, especially prepared for use in the E-A writing system is available in red or green color in 2-ounce, 1 pint and gallon bottles.

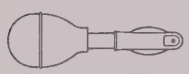
Accessory Kit

The AW Accessory Kit is housed in a cardboard box as shown above. Each kit contains a 2-ounce bottle of ink, pen filler, inkwell filler and pen point cleaner.

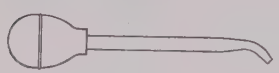
Pen Point Cleaner



Pen Filler



Inkwell Filler

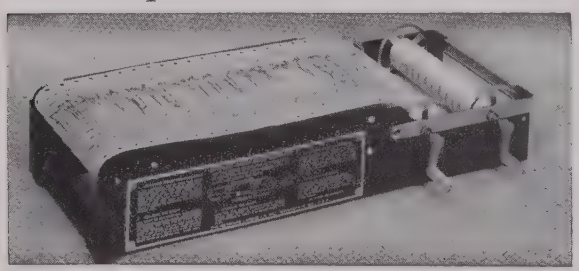


Pen point cleaner, pen filler and inkwell filler can be purchased separately or in the kit, above

Pen Points

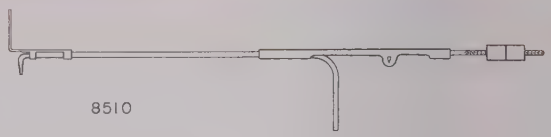
No. 82-M—Replaceable pen points. These are illustrated in pen elements 8510, 9056 and 9112 in the next column.

Chart Inspector



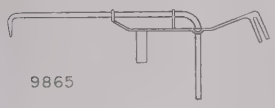
The chart inspector is a convenient tool for inspecting records, making notes on them and re-rolling them for filing.

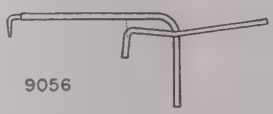
Pen Elements



No. 8510—AW Standard pen element for ammeters, milliammeters, voltmeters, wattmeters, etc. 6 5/16″ long over-all.

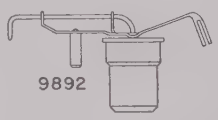
No. 3154—LR-MS Standard pen element, 5 7/8″ long over-all. (Not illustrated but similar to No. 8510)

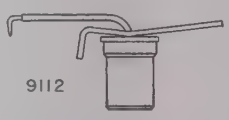




No. 9865—One-piece, for AW operation recorders above serial No. 30782 (supersedes 9856 which had a replaceable pen point).

No. 9056—For AW operation recorders below serial No. 30782.





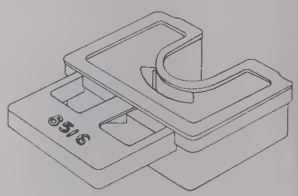
No. 9892—AW chronograph pen element and inkwell assembly. Give serial number.

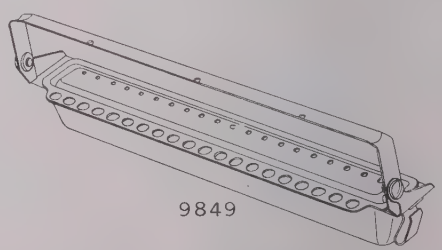
No. 9112—AW chronograph pen element and inkwell assembly. Give serial number.

Inkwells

No. 8516—AW Standard inkwell with cover.

No. 4038—(Not illustrated)—LR Standard inkwell with cover.





No. 9849—Inkwell with stainless steel body, for AW operation recorders above serial No. 30782.

No. 9050—For AW operation recorders below serial No. 30782. (Not illustrated)

THE ESTERLINE-ANGUS COMPANY

Pioneers in the Manufacture of Graphic Instruments

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Catalog Section 90
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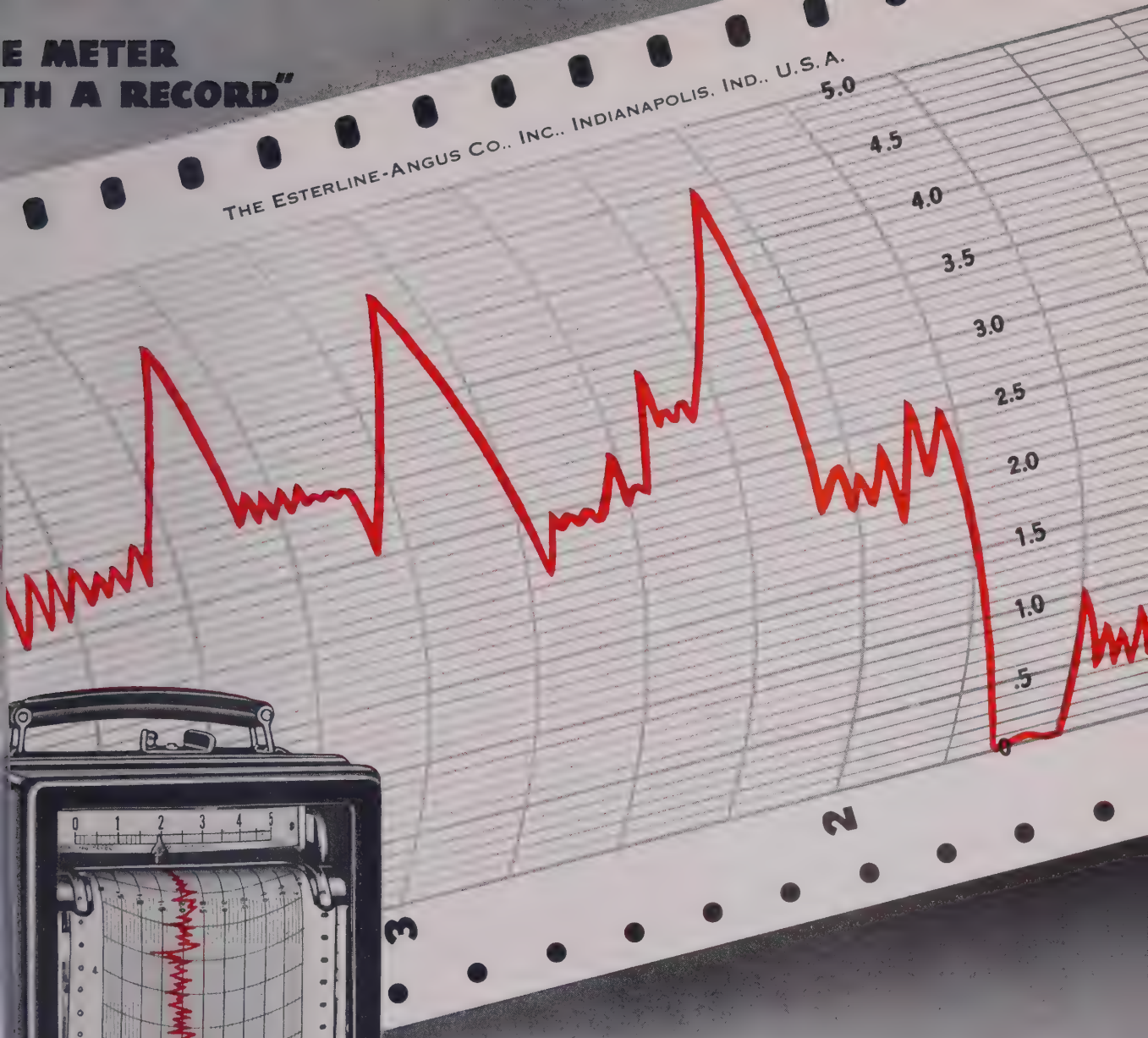
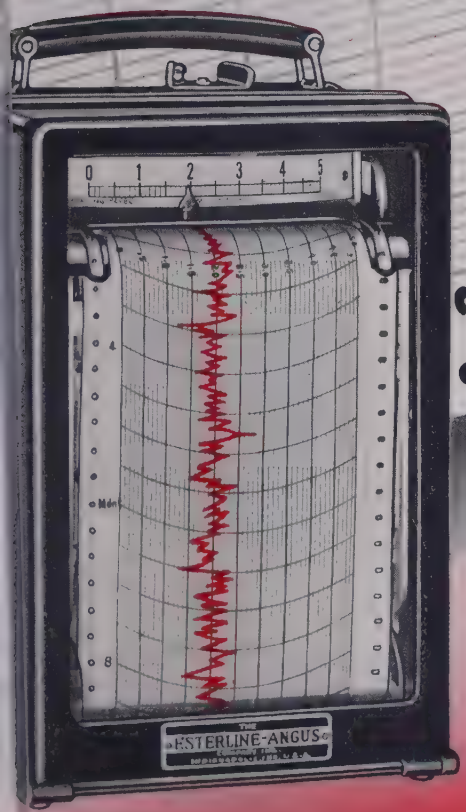




THERE IS AN

ESTERLINE-ANGUS GRAPHIC INSTRUMENT

to get the facts you want

CATALOG NO. 657-B

GRAPHIC RECORDERS

Modern civilization depends heavily on measurement. The development of measuring instruments had a tremendous influence upon the improvement of existing equipment, and the development of new devices and processes. Railroads, electric utilities, radio stations and other communication facilities, steel mills, chemical works, automotive and aircraft plants, airlines, scientific and medical research laboratories, government research and experimental installations, national defense installations, all have a basic similarity in that they use measuring instruments to obtain accurate and unbiased information.

Measuring devices secure the facts which lead to better service, new and better products, greater safety, and more economical operation. *Recording* instruments are especially important in our modern economy because they gather information automatically and continuously without requiring the presence of a human operator.

Operating Conditions

Recording instruments are required to operate under every conceivable condition. They are used in damp places; in atmospheres laden with metallic dust; in the presence of fumes and gases; in vehicles and in aircraft. Such operating conditions call for excellence in design, workmanship and materials.

Many recording instruments are in service twenty-four hours a day, every day in the year. Recorders

FIG. 1—*Here are 3 of 11 Operation Recorders which tally production of 18,000 automobile inner tubes per day. (Goodyear Tire and Rubber Co. photo)*

FIG. 2—*An Esterline-Angus Recording Milliammeter housed in a portable case. The chart is 6 inches wide with an active width of 4½ inches.*

are frequently part of a permanent installation which is expected to last for many years, and they should, therefore, have a life comparable with the heavy apparatus with which they are used.

As processes change with new developments, it is desirable that it be possible to change instrument characteristics with a minimum of expense to handle the new conditions.

All of these conditions call for instruments with the maximum practical accuracy and flexibility along with the ruggedness and simplicity which result in low maintenance cost.

50 Years of Instrument Design

The present design of Esterline-Angus recording instruments is the culmination of 50 years of experience in this highly specialized field. We have built to meet the demand of those purchasers who want the best—as measured by a high standard of performance and a low cost per unit of satisfactory service.

On the following pages are some of the more pertinent details concerning "The Meter With a Record." If you wish additional information or a quotation, one of our many qualified product representatives is at your service.

ELECTRODYNAMOMETER MEASURING ELEMENTS

For measuring current, voltage, vars, power factor and frequency in AC circuits, and power in either AC or DC circuits, electrodynamometer measuring elements are normally used. These usually consist of two coil groups: fixed field coils, and movable armature coils. Rotation of the movable coils is the result of torque produced by interaction of the magnetic fields created when current is flowing through both sets of coils. Rotation is usually opposed by "torque" springs, which also determine the zero position when the instrument is not energized.

Direct Writing

The writing pen, attached to the moving system, is an ink-on-paper type, requiring no relays, balancing circuits, linkages or servo systems for its operation.

All Esterline-Angus dynamometer instruments are basically of the 2-element type. The two movable coils are mounted on a single staff which rotates within the two sets of stationary coils. This makes possible an astatic movement—one in which the effect of a uniform external magnetic field (such as the earth's field) is nullified, and hence eliminates a possible source of error.

Elements Are Interchangeable

Final assembly of a measuring element includes completing all electrical connections to terminal boards, which become an integral part of the element. The element is thus a complete working unit, which can be installed in or removed from the case without disturbing any of the connections. Careful attention was given to the design of this unit assembly to permit transfer or interchange of measuring elements in the various types of Esterline-Angus cases. Thus it is possible to replace one type of dynamometer element with another or to interchange a dynamometer measuring element with a permanent-magnet moving-coil element without modification of any component. Replacement of an electrical element with one measuring pressure or position is also possible, but in certain instances requires a minor modification of the case.

Stable Characteristics

Sustained accuracy of an instrument depends upon every part retaining its original position and shape, independent of age, temperature or mechanical shock. All Esterline-Angus electrodynamometer recorders have measuring element parts mounted on a single heavy, rigid bakelite frame, which not only has excellent physical stability, but also insures a high insulation value—several times that commonly found in other makes.

Protection from Ink

In the design of this element, care has been taken to prevent spilled ink from reaching any of the electrical windings. The upper bearing support is protected so that ink cannot flow down around it; the staff carries a canopy which prevents spilled ink from reaching the bearing. A drain is provided to carry away excessive spillage from the recess in which the inkwell rests.

Adjustable Damping

The damping is magnetic, accomplished by an aluminum disc which swings across the poles of Alnico magnets secured to the bottom of the bakelite frame. In each type of measuring element, the damping is properly proportioned to the inertia and torque of the moving system, and is adjustable over a considerable range.

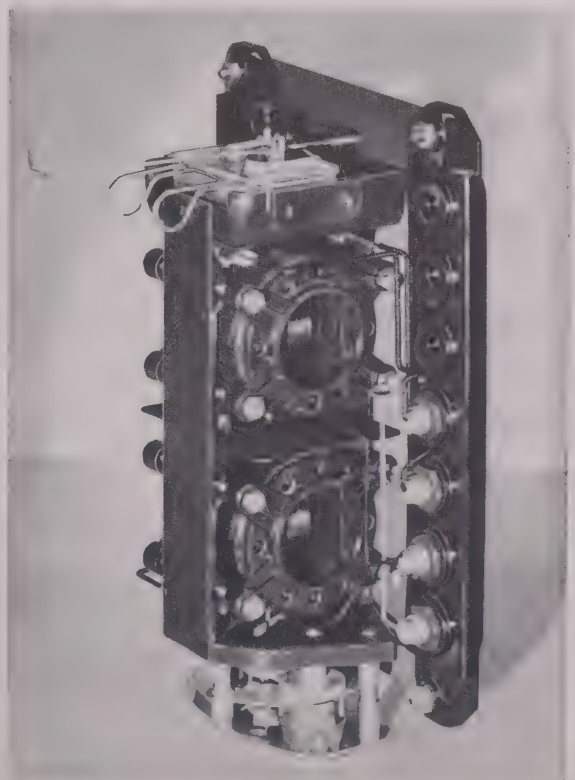


FIG. 3—*The electrodynamometer measuring element used in Esterline-Angus AC instruments. Note the rigid molded bakelite frame which maintains all parts in accurate alignment.*

FIG. 4—*An Esterline-Angus recorder showing the load on a sand muller. The record helps the operator to mix ingredients consistently.*

AC AMMETERS (Catalog Section 30)

Ampere Range	Burden in VA 60 Cycles	Frequency Limits for 1% Accuracy (Cycles)
0-5	9.5	25-400
0-7.5	15.0	25-240
0-10	9.5	25-400
0-15	15.0	25-240
0-20	9.5	25-400
0-5/10	9.5	25-400

For ranges below 0-5 amperes, the rectifier type instrument (Catalog Section 48) is recommended.

Response time is approximately 1.15 seconds. Accuracy is 1% of full scale current. Portable meters have 5-foot leads. AC ammeters have left hand zero only.

When operated on circuits above 800 volts, a current transformer must be used.

AC WATTMETERS (Catalog Section 33)

(2-element)

Nominal ratings of 5-ampere instruments:

Kilowatts (Self-Contained)	Volts	
1.0	100	Burdens at 60 cycles:
2.0	200	
5.0	500	Each current circuit
1.0/2.0	100/200	9.5 VA.
1.0/5.0	100/500	Each 100 Volt poten-
2.0/5.0	200/500	tial circuit at 120
1.0/2.0/5.0	100/200/500	volts, 6.3 VA.

2-element AC wattmeters are primarily for use on single-phase 2- and 3-wire; 2-phase 3-, 4- and 5-wire; and 3-phase 3-wire circuits. Standard frequencies are 25 to 60 cycles, special instruments being available for 400 cycles.

Response time is approximately 1¼ seconds. Accuracy is 1% of full scale watts. Portable meters have 5-foot current and potential leads. AC wattmeters can have zero at any point between the left hand side and center of scale.

AC WATTMETERS (Catalog Section 33)

(3-current and 4-current-element)

Nominal ratings of 5-ampere instruments:

Kilowatts (Self-contained) 3-current-element	4-current-element	Volts
1.5	1.0	100
3.0	2.0	200
7.5	5.0	500

The burden of each current circuit does not exceed 3 VA at 5 amperes, 60 cycles. The burden of each potential circuit does not exceed 6 VA at 120 volts, 60 cycles.

3-current-element wattmeters are for use primarily on 3-phase 4-wire star-connected circuits. Standard frequencies are 25 to 60 cycles, special instruments being available for 400 cycles.

4-current-element wattmeters are for use on any single phase, 2-phase, or 3-phase circuit, including 3-phase, 4-wire delta-connected circuits for combined lighting and power.

Response time is approximately 1 second. Accuracy is 1% of full scale watts. Portable meters have 5-foot current and potential leads. The zero can be at any point between the left hand side and center of scale.

DC AND AC-DC (UTILITY) WATTMETERS (Catalog Section 33)

Nominal ratings:

Kilowatts (Self-contained)	Volts
1.0	100
2.0	200
5.0	500

Current circuits are rated 5 amperes, 100 MV at shunt end of leads. The burden of each current circuit does not exceed 1 VA at 5 amperes. The burden of each potential circuit does not exceed 8 VA at 120 volts.

DC wattmeters are for use on DC 2-wire or 3-wire, with 100 millivolt shunts. Utility (AC-DC) wattmeters are for use on either AC or DC.

Response time is approximately 1 second. Accuracy is 2% of full scale watts. All meters have 5-foot current leads. Portable meters also have potential leads. The zero can be at any point between the left hand side and center of the scale.

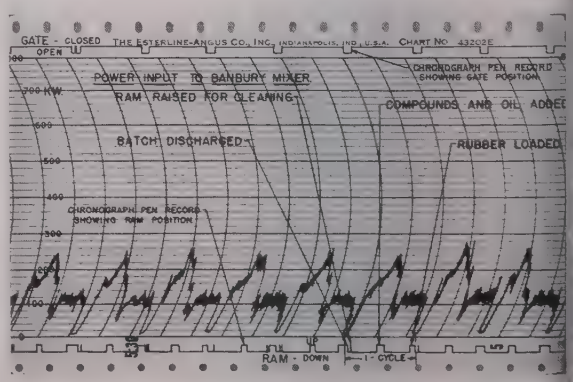


FIG. 5—*Chart showing power input to motor driving a Banbury mixer during compounding of rubber. The power required increases as compounds and oils are added. Operation of mixer ram and gate are shown by chronograph pens.*

For further information ask for the Catalog Section shown.

AC VOLTMETERS (Catalog Section 30)

Voltage Range	Full Scale Current (Amps.)	
0-50	0.38	
0-100	0.18	The burden of the 0-150 volt range at 120 volts is approximately 12.5 VA.
0-150	0.13	
0-300	0.13	
0-600	0.13	
0-750	0.13	

Combinations of most of the standard ranges between 0-50 volts and 0-750 volts AC are available The most frequent combination is 0-150/300/600 volts. Standard frequencies are 25, 50 or 60 cycles. Rectifier type recorders (Catalog Section 48) should be used for multi-frequency and for AC-DC service.

Response time is approximately 1.3 seconds. Accuracy is 1% of full scale voltage. Portable meters have 5-foot leads. AC voltmeters have left hand zero only.

POWER FACTOR RECORDERS
(Catalog Section 37)

Single and Polyphase

Nominal Rating Amperes	Volts	Current Circuit Burden at 5 amps., 60 Cycles
5	120	Polyphase—19 VA
5	240	Single Phase—19 VA
5	480	Potential Circuit Burden at 120 volts, 60 Cycles
5	120/240	
5	120/480	Polyphase—19 VA
5	240/480	Single Phase—25 VA
5	120/240/480	

Polyphase power factor recorders are for use on balanced 3-phase, 25 to 60 cycle circuits where the direction of power flow is the same at all times. Single phase recorders are for use primarily on single phase, 60 cycle circuits but can be supplied with a separate network for use on 3-phase, 3-wire, 60 cycle circuits.

Response time is approximately 1¼ second at rated voltage and current. Accuracy is 1% of the scale width on the polyphase meter and 1½% on the single phase meter, when operated with 2 amperes or more in the current circuit, and at rated voltage.

FIG. 6—*A steel mill switchboard containing 65 graphic recorders. Many of the instruments are wattmeters measuring the power input to large motors.*

FIG. 7—*A portable wattmeter in use on an automatic screw machine. Records obtained are useful for studies of production time, coolants, speeds, tools and materials.*

FREQUENCY RECORDERS
(Catalog Section 38)

Frequency Range (Cycles Per Second)	Voltage Rating	
45-55	120	The burden is approximately 10.5 VA unity power factor, at 120 volts
55-65	120	
46-66	120	
20-30	120	

Frequency recorders can be operated continuously on voltages between 100 and 135 volts.

Response time is 1 to 2 seconds depending on range and applied voltage.

Accuracy is 2% of active scale width. (This is 0.2 cycle in the center third of a 55-65 cycle recorder.) Portable meters have 5-foot leads. Frequency recorders have no torque springs and, hence, no free zero.

KVA AND KVAR RECORDERS
(Catalog Section 35)

2- or 3-current-element

Nominal ratings (5-ampere current circuits):

KVAR OR KVA (Self-contained) 2-element	3-element	Volts
1.0	1.5	100
2.0	3.0	200
1.0/2.0	1.5/3.0	100/200

Polyphase KVA and KVAR measurements may be made on 3-phase, 3-wire circuits by using a standard 2-element wattmeter and a phase shifting network, and on 3-phase, 4-wire star circuits by using a 3-current-element wattmeter and a phase shifting network. Power flow must normally be in a single direction for KVA measurements, limiting such recorders to left hand zero. KVAR recorders may be supplied with zero at any point between the left hand side and center of scale. Some KVAR measurements can be made without the use of a network.

Response time is approximately 1¼ seconds. Accuracy is 1½% of full scale reading. Portable instruments have 5-foot leads.

For further information ask for the Catalog Section shown.

PERMANENT-MAGNET MOVING-COIL RECORDERS

Measurements of current and voltage in DC circuits are usually made with a permanent-magnet moving-coil element. This measuring element, often referred to either as the PMMC or d'Arsonval movement, employs two Alnico V magnets to produce the intense magnetic field in which the armature coil moves. The principle of motion is the same as that of an electric motor: a current-carrying conductor in a magnetic field is acted upon by a force which tends to move the conductor in a direction at right angles to the direction of the field.

The direction of the motion is reversed if the direction of the current in the conductor is reversed. The rotation of the coil is opposed by springs which return the coil to a fixed zero position when no current is flowing.

The writing pen, attached directly to the moving system, is an ink-on-paper type, requiring no relays, balancing circuits, linkages or servo systems for its operation.

All electrical connections are made to attached terminal boards when an element is placed in the instrument case. The element thus is a complete working unit and can be removed from the case without disturbing any of the connections to it. Careful attention was given to the design of this unit assembly to permit transfer or interchange of measuring elements in the various types of Esterline-Angus cases. Thus it is possible to replace one type of dynamometer element with another or to interchange a dynamometer measuring element with a permanent-magnet moving-coil element without modification of any component. Replacement of an electrical element with one measuring pressure or position is also possible, but in certain instances requires a minor modification of the case.

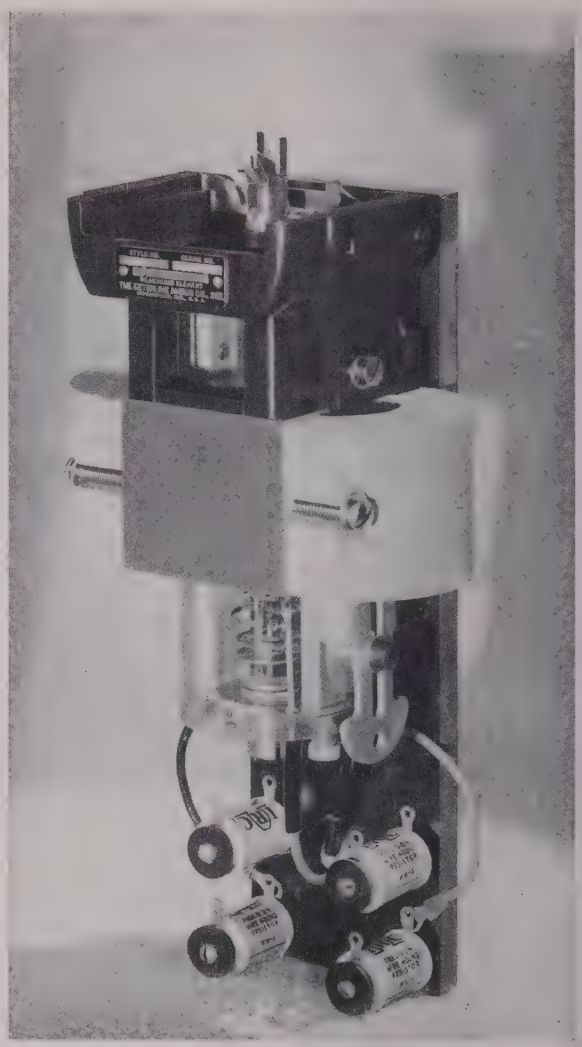


FIG. 8—*The permanent-magnet moving-coil measuring element used in Esterline-Angus DC instruments.*

Mechanism Well Protected

Protection from dust, dirt and mechanical damage is given to the internal portions of the measuring element by transparent plastic shields. With this protection, there is little possibility of dirt or magnetic particles gaining access to the air gap. This feature is important where the meter is exposed to flying scale or magnetic dust. Further protection is given the user and the instrument by the use of a bakelite plate on which the measuring element is mounted. This unit has been constructed to withstand an insulation test of 5,000 volts AC, an important feature when the instrument is used on high DC voltages.

In the design of this element, care has been taken to prevent spilled ink from reaching the armature coil. The upper bearing support is protected so that ink cannot flow down around it; the staff carries a canopy which prevents spilled ink from reaching the bearing. A drain is provided to carry away excessive spillage from the recess in which the inkwell rests.

Sensitivity and Damping

Damping of the moving element is produced chiefly by the eddy currents which flow in the metallic frame of the moving coil as it rotates in the magnetic field, and secondarily by the effect of current flow in the circuit connected to the instrument. There is no appreciable over-shooting. The sensitivity of this element makes it possible to provide DC ammeters which will come to full scale on as low as 30 millivolts, and milliammeters with the low range of 0-1 MA.

DC MICROAMMETER (Catalog Section 41)

Range is 0-50 microamperes DC with input resistance of approximately 200 ohms. Accuracy is 2% of full scale reading. The instrument consists of a permanent-magnet moving-coil measuring element combined with a reliable magnetic amplifier. It normally operates on a 120 volt 50-400 cycle source but can be ordered to operate on 12 volts DC.

DC MILLIAMMETERS (Catalog Section 42)

Range in Milliamperes	Volts Drops at Full Scale	Resistance in Ohms
0-1	1.4	1400
0-5	0.35	70
0-10	2.0	200

Accuracy is 1% of full scale reading.

The response time of DC Milliammeters is 0.5 second, when critically damped. They may be calibrated for either left-hand zero, center zero or offset zero. Multi-range instruments are available, using either the 0-1 or 0-5 MA element.

DC AMMETERS (Catalog Section 40)

Millivolts		
0-50	0-200	DC Ammeters or Millivoltmeters
0-75	0-300	with left-hand zero consume
0-100*	0-600	0.150 ampere at full scale.
0-125	0-750	
0-150	0-800	

*100 MV rating is used where we furnish both the meter and the shunt.

Response time is approximately 1 second for 0-100 MV meter. Accuracy is 1½% of full scale reading. All DC ammeters have calibrated leads 5 feet long. Normal calibration is for left-hand zero, but center zero or offset zero instruments can be supplied. Intermediate calibrations can be supplied.

FIG. 9—*Generators measure speed of steel as it is processed in electro-galvanizing line.*

DC VOLTMETERS (Catalog Section 40)

0-2
0-5
0-10
0-25
0-50
0-75
0-100
0-150
0-200
0-250
0-500
0-800
0-1000 }
0-1500 } For use only on grounded circuits.

Left-hand zero meters have a resistance of 200 ohms per volt and a full scale current consumption of 5 MA. Center zero meters are 400 ohms per volt and current is 2.5 MA at either full scale point. Special high resistance voltmeters of 1000 ohms per volt can be furnished.

Response time is approximately 0.5 second. Accuracy is 1% of full scale reading. Portable meters have 5-foot leads. Multi-range instruments can be provided. Intermediate calibrations can be supplied.

DC MILLIVOLTMETERS AND DC MILLIVOLT-VOLTMETERS (Catalog Section 40)

Range		
MV	V	
0-50	0-1	Left-hand zero meters have a full
0-75	0-2	scale current of 150 MA. Center zero
0-100	0-5	meters have a current of 75 MA at
0-125	0-10	either full scale point.
0-150	0-25	
0-200	0-50	These instruments are for use as either
0-300	0-100	a DC voltmeter, or a DC ammeter,
0-600	0-150	by combining millivolt and volt ranges
0-750	0-300	in a single instrument.
0-800	0-600	

Response time is approximately 1 second for 0-100 MV range and 0.5 second for 0-300 MV and higher ranges. Accuracy is 1½% of full scale reading. All instruments have calibrated 5-foot leads.

SPEED RECORDERS (Catalog Section 46)

A speed recorder consists of a recording DC voltmeter operated from a permanent-magnet type DC generator and calibrated in revolutions per minute, miles per hour, feet per minute, knots, processing time in minutes, etc. Accuracy of the recorder and generator is 1½% of full scale reading.

RECTIFIER RECORDERS (Catalog Section 48)

The permanent-magnet, moving-coil measuring element, with a rectifier, provides a means of recording AC and DC amperes, milliamperes and volts in a single instrument, having an evenly divided scale.

Ranges	
0-50 MA AC	Many combinations of both
0-1 to 0-10 A AC	AC and DC ranges can be
0-50 to 0-800 V AC	supplied.
0-100 MV to 0-800 V DC	

For further information ask for the Catalog Section shown.

OTHER RECORDERS

In addition to the electrodynamometer and PMMC types of recorders, The Esterline-Angus Company manufactures instruments which incorporate other types of electrically and mechanically actuated measuring elements. Most of these can be used interchangeably in all types of cases, and in conjunction with any type of chart drive.

OPERATION RECORDERS
(Catalog Section 50)

The operation recorder is a multi-pen instrument. Each pen is operated by an individual electro magnet. When the circuit to any one of the magnets is closed, the pen operated by this magnet is moved laterally across the chart about 1/10 inch from its "off" position and it remains there as long as the circuit is energized. An instrument of this type is used for recording time of occurrence, sequence, and duration of a number of events, such as opening and closing of valves, relays, doors, switches, circuit breakers and telephone circuits. It is also widely used as a production recorder, to show the active and idle periods of both automatic and manually operated equipment and processes.

One inkwell serves all pens. The pen tubes are pivoted in holes in the top of the inkwell, and engage lever arms which are linked by a spring to the electromagnets which operate the pens. A single instrument case will accommodate any number of pens from five to twenty, while twin cases will accommodate a maximum of forty pens.

Pen Coil Ratings

Minimum DC Rating—2 volts
Maximum DC Rating—250 volts
Minimum 25 Cycle Rating—3.5 volts
Maximum 25 Cycle Rating—240 volts
Minimum 50-60 Cycle Rating—6 volts
Maximum 50-60 Cycle Rating—240 volts

The power required to operate each circuit in the operation recorder ranges from 0.9 to 6.5 watts, depending upon rating.

The speed of response of the elements is such that they will follow as many as 10 complete "on-off" cycles per second, provided the "on" and "off" times are substantially equal.

Operation recorders can be operated continuously on potentials 15% below or in excess of normal rating.

PRESSURE AND VACUUM RECORDERS
(Catalog Section 60)

Permanent records of pressure and vacuum are vital guides in the operation of many types of equipment, and in the conducting of a wide variety of tests in industrial, research and development projects.

For pressure ranges from 0-25 to 0-6,000 PSI, Bourdon tube elements are used.

For pressure ranges from 0-25 inches of water to 0-15 PSI, and for vacuum, a bellows type element is used to obtain the forces necessary to operate the movement. The one-piece cylindrical brass bellows, has one side restrained while the other is permitted to move when pressure or vacuum is applied.

Ranges	Type of Element	
PRESSURE		
Minimum 0-1 PSI Maximum 0-15 PSI	—Bellows	Many intermediate ranges can be supplied.
Minimum 0-25 PSI Maximum 0-6000 PSI	—Bourdon Tube	
VACUUM		
0-30 Inches of Mercury	—Bellows	
VACUUM-PRESSURE		
30-0-30 Inches of Mercury	—Bourdon Tube	

Bellows pressure elements have a total internal volume of approximately 15 cu. in., including connecting tubing. Volume of Bourdon tube elements is approximately 1½ cu. in.

The undamped instrument will swing across scale in approximately 0.1 second. Accuracy is 2% of full scale reading.

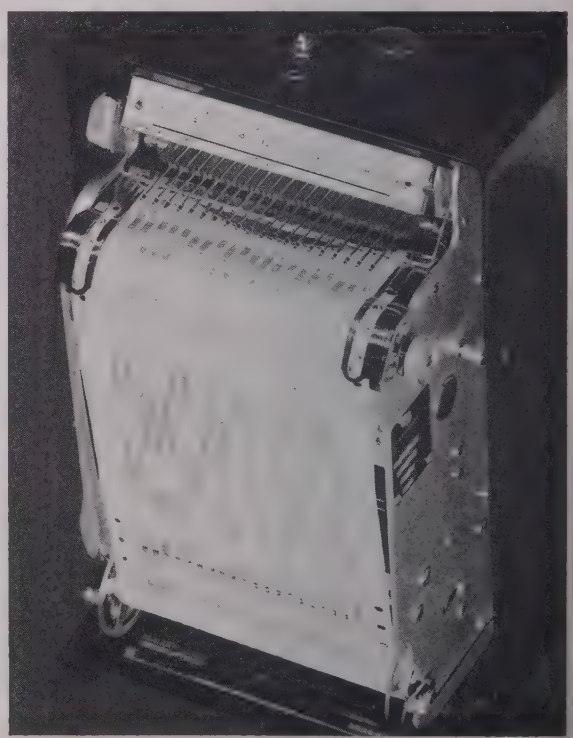


FIG. 10—*Raising the scaleplate automatically raises the pens from the chart in an Esterline-Angus Operation Recorder.*

For further information ask for the Catalog Section shown.

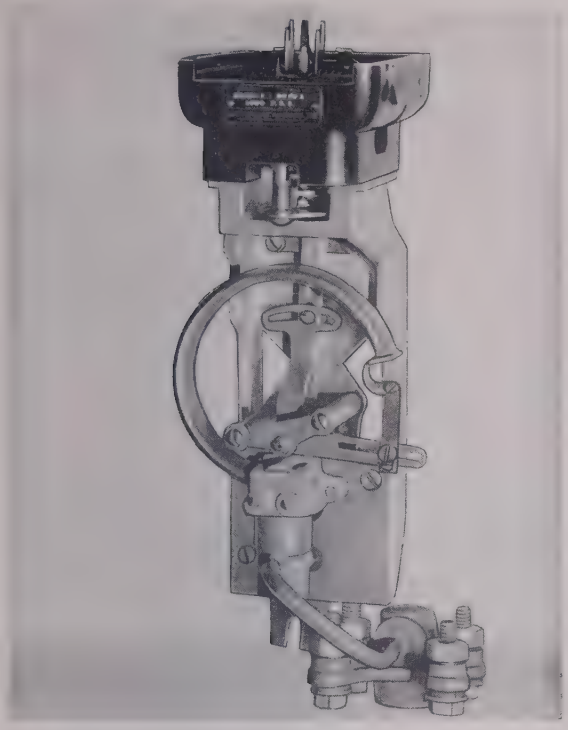


FIG. 11—*An Esterline-Angus Bourdon tube pressure measuring element.*

POSITION RECORDERS (Catalog Section 65)

These instruments are used to record position and motion of machine tool parts, molding dies, control levers, etc., and can be furnished in either a mechanical or electrical type.

In the mechanical type, the recording pen is operated by means of a rotatable shaft, projecting from the left side of the recorder case. This shaft is geared to the staff which carries the writing pen. Rotary motion can be recorded by direct gear connection to the recorder shaft. Straight-line motion can be recorded by a rack and pinion, a cable drum, or a chain and sprocket arrangement.

In the electrical type, the recording pen is geared to a Selsyn motor mounted inside the instrument, thus recording the position of a remote Selsyn transmitter, which may respond to the movement of a weighing scale, the position of lock gates, the rotation of a radar antenna, or the height of charge in a blast furnace.

Rotation of Shaft for Full Scale Deflection

Mechanical Type	Selsyn Type
Minimum—12.4°	Minimum—62°
Maximum—309.5°	Maximum—345°

Zero is usually at left side of scale. However, zero can be set at any point on the scale by shifting connection to projecting shaft. Accuracy is 0.5% of full scale rotation of external shaft on the recorder or on the transmitting Selsyn.

CONTACT-MAKING INSTRUMENTS

(Adjustable Calibrated Relays) **(Catalog Section 70)**

An Esterline-Angus contact-making instrument consists of a standard recorder measuring element, fitted with pointer and scale, but no writing mechanism. The measuring element carries a pair of spring-mounted moving contacts, which swing between two adjustable stationary contacts. These stationary contacts can be set at any desired maximum and minimum value on the scale. Recording and contact-making features cannot be combined in one instrument. Any of the following measuring elements can be furnished in a contact-making instrument:

AC Amperes
AC Volts
AC Watts
KVA
KVAR
Power Factor
Frequency
Speed
DC Amperes
DC Volts
DC Watts
DC Milliamperes
DC Millivolts

Contacts are rated at ¼ ampere, 250 volts maximum. Contact-making meters are usually furnished with inside adjusting levers for setting contacts. External adjusting knobs can be supplied, except on flush or portable cases.

Accuracy is the same as corresponding recorder plus 1%.

FIG. 12—*Contact-making instrument with cover removed, showing ease of adjusting contacts on direct-reading scale.*

For further information ask for the Catalog Section shown.

CHART DRIVES

(Catalog Section 20)

Of major importance in selecting a recording instrument is the method for handling the record chart at various chart speeds.

All Esterline-Angus recorders use charts 6 inches wide and 103 feet long. There are five fundamental methods of driving the chart, and more than 50 combinations or variations of these basic methods.

All chart drives are mounted on rigid aluminum frames and all have identical mounting holes. This feature makes it possible to replace one type of chart drive with another, or to exchange chart drives between instruments. The box-like construction maintains alignment of all parts, which reduces friction in the gear train, and makes possible smooth feeding of the chart.

A wide variety of standard speeds is available, covering a range from ¾″ per hour to 3″ per second. It is important to give careful consideration to the possible variations in the quantity to be measured and then select a chart speed or group of speeds which will be adequate to obtain the desired type of record.

HAND-WOUND SPRING CHART DRIVES

A hand-wound spring drive is used where electric power is not available or where the instrument must be entirely independent of any power supply.

A high quality escapement with temperature compensation provides accurate timing for 8 days with one winding of the springs at any of the hour feeds. A flyball governor controls the minute speeds, one winding providing operation for 3½ hours.

Hour feed drives provide all of the following speeds—¾, 1½, 3, 6 or 12 inches per hour.

Minute feed drives provide all of the following speeds—¾, 1½, 3, 6 and 12 inches per hour and per minute.

On minute feed drives, the shift from inches per hour to the corresponding speed in inches per minute is accomplished manually by moving a lever on the side of the drive or, where the change must be made from a remote point, the drive can be equipped with an electric gear shift.

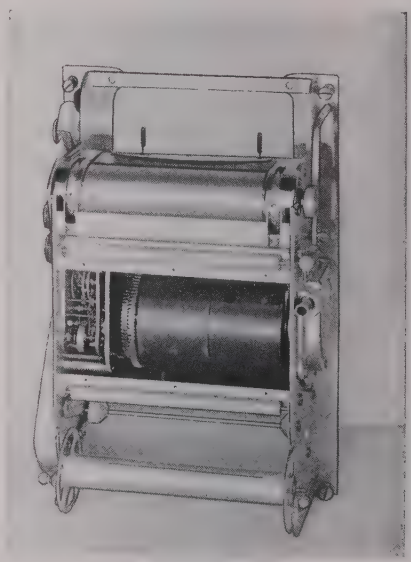


FIG. 13—*Hand-wound spring chart drive with coverplate removed, showing escapement and spring housing.*

MOTOR-WOUND SPRING CHART DRIVES

A motor-wound spring drive is applicable where AC power is available, but not regulated, or where the chart drive must keep running through a power interruption.

The chart speeds in this type of drive are controlled by an escapement and flyball governor identical with that used in the hand-wound spring drive; the chart speeds are also identical.

The power required to wind the springs in this drive is provided by a torque motor, which is intermittently energized. Motors are available for operation on 120 or 240 volts, 25, 50 or 60 cycles. A separate motor of the same type is used to power the chart reroll mechanism. Operation at any of the hour feeds will continue for approximately 5 hours after a power interruption.

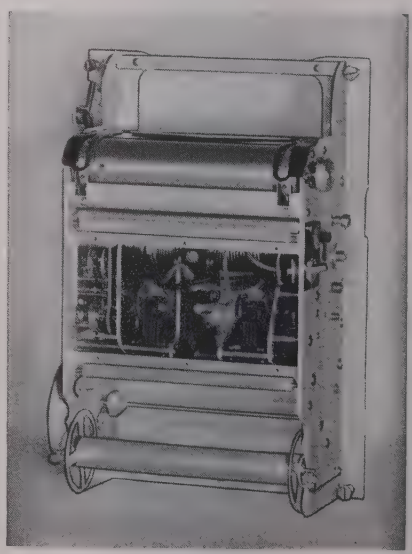


FIG. 14—*Motor-wound spring chart drive with coverplate removed, showing escapement, winding and reroll motors.*

For further information ask for Catalog Section 20.

SYNCHRONOUS CHART DRIVES

A synchronous motor chart drive is used where a source of frequency-regulated AC is available and where it is not necessary for the record to continue during power supply interruptions.

Synchronous chart drives provide all of the following speeds—¾, 1½, 3, 6 and 12 inches per hour and per minute.

The motive power in this type of drive is a self-starting, synchronous motor, which is lubricated for the life of the unit by means of an oil reservoir and felt wicks. This motor can be supplied for operation on 120 or 240 volts, 25, 50 or 60 cycles. The chart reroll mechanism is driven by a separate torque motor.

On minute feed drives, the shift from inches per hour to the corresponding chart speed in inches per minute is accomplished manually by moving a lever on the side of the drive or, where the change must be made from a remote point, the drive can be equipped with an electric gear shift.

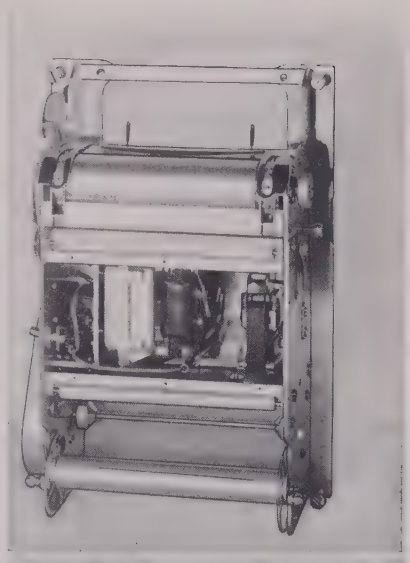


FIG. 15—*Synchronous chart drive with coverplate removed, showing timing motor, reroll motor and electric shift.*

PHANTOM CHART DRIVES

A phantom drive is one having standard chart carrying parts, but no built-in propelling power. It depends on being driven by some external device. One primary use of the phantom drive is where two meters are coupled together, as in a twin instrument. A spring or synchronous drive used in one side of the twin supplies the power and timing, and a phantom drive is used in the other.

The second use of the phantom is where chart motion is not to be proportional to time but is proportional to some motion external to the meter, such as movement of the ram on a hydraulic press, rotation of a radar antenna, or travel of a car used in checking field strength of a broadcasting station.

Standard chart movement is ¾, 1½, 3, 6 or 12 inches per revolution of the coupling shaft.

The phantom drive may be equipped with a spring-wound reroll or an electric reroll as desired.

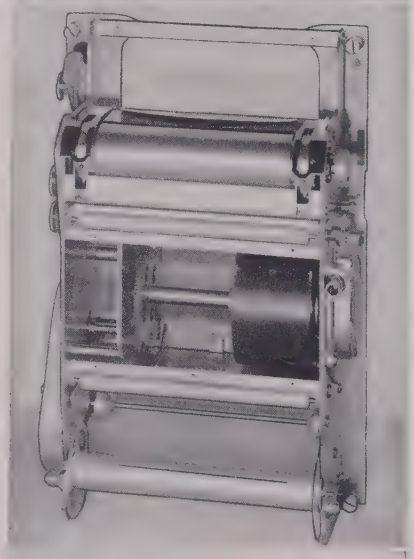


FIG. 16—*Phantom chart drive with coverplate removed, showing spring housing.*

EXTERNAL MOTOR ATTACHMENTS

Where chart speeds above 12″ per minute are desired, an external motor attachment is employed, to provide speeds of ¾, 1½, or 3 inches per second. The motor with its reduction gears and shifting mechanism is a unit assembly, and is attached to the side of the meter case. Electrical ratings are 12, 24, 48, 125 or 250 volts DC, 120 volts, 60 cycles, AC.

An external motor can be applied in combination with any of the internal chart drives described on these pages. In general, the most suitable speed is ¾″ per second, although higher speeds are available, and are necessary on certain applications.

Two forms of the external motor attachment are available. In one form, Type N, the chart advances from inches per hour to inches per second, when its motor is energized. It reverts to inches per hour any time that the initiating impulse is removed. The other form, Type R, is for fault recording. It starts in the same way but continues to run for a predetermined length of time and resets the chart to the correct time of day.

FIG. 17—*Portable instrument with external motor attachment.*

For further information ask for Catalog Section 20.

INSTRUMENT CASES

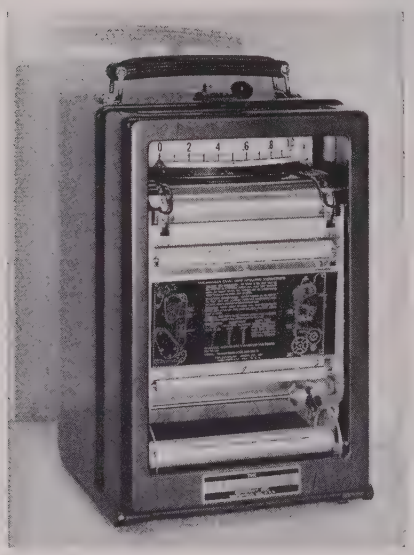
(Catalog Section 15)

Esterline-Angus instruments are furnished in four types of cases, namely, portable, flush switchboard, front switchboard and wall mounting. With the exception of the portable style, all can be furnished as twin cases.

The meter case consists of two aluminum alloy die castings, the case proper and the case cover or door. Castings of this material are light, yet tough enough to withstand rough usage.

Accurately located bosses are provided for mounting the measuring element, terminal blocks and chart drive. This makes possible the transfer of measuring elements and chart drives between cases. Such transfers can be made quickly and easily by the user, since the measuring element and drive are each unit assemblies.

All cases are finished with dull black baked enamel and all trim is heavily nickel plated and polished.



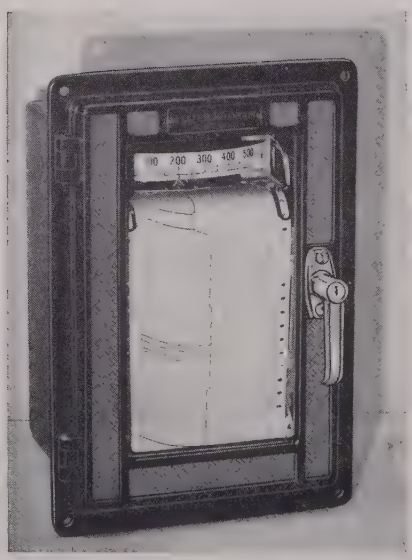
PORTABLE

A portable instrument is fitted with a steel reinforced rubber handle securely fastened to the top of the case. The entire front of the case cover is glass, and there is also a small top window, which makes the chart and scale easily visible from the front and from above the instrument. The front cover is hinged at the bottom, and is easily detached from the case.

Physical Details			Approx. Weight with Measuring Element and Chart Drive
Height*	Width	Depth†	
15¼″	8 9/16″	9 5/16″	34 lbs.

*This dimension is from the bottom of the case to the top of the handle in normal position.
†This dimension does not include multiplier. Add 2¾″ if instrument has attached multiplier.

FIG. 18—*Portable recording wattmeter.*



FLUSH SWITCHBOARD

For permanent mounting, most modern installations utilize flush switchboard cases. The case cover is hinged at the left side, and has a sturdy handle and lock at the right. The chart and scale are illuminated by a 4 watt, 120 volt, 60 cycle fluorescent lamp. On DC and 25-50 cycles, a 15 watt, 125 volt incandescent lamp is furnished.

Physical Dimensions			Approx. Weight with Measuring Element and Chart Drive
Height*	Width*	Depth†	
16″	10 9/16″	8¾″	38 lbs.

*These dimensions apply to the front flange.
†This dimension does not include multiplier. Add 2¾″ if instrument has attached multiplier. The maximum projection from front of panel is $2\frac{9}{16}$″.

FIG. 19—*Recording DC Milliammeter in single flush case.*

For further information ask for Catalog Section 15.

FRONT SWITCHBOARD

Front switchboard cases are arranged for front-of-board mounting with studs for rear-of-board connections on metallic or non-metallic panels of any thickness. The case front is identical with that used on portable instruments.

Physical Dimensions			Approx. Weight with Measuring Element and Chart Drive
Height*	Width	Depth	
14"	8¾"	9¼"	34 lbs.

*This dimension is from the bottom of the case to the top of the latch.

FIG. 20—*Operation Recorder in single front switchboard case.*

WALL MOUNTED

Wall type cases are arranged so that instruments can be mounted on a flat vertical surface and connections made by means of conduit, BX cable or open wiring entering from the bottom of the connection compartment. The case front is identical with that used on portable instruments.

Physical Dimensions			Approx. Weight with Measuring Element and Chart Drive
Height*	Width	Depth	
15 1/16"	8⅝"	10 15/16"	38 lbs.

*This dimension is from the extreme bottom to extreme top of mounting lugs.

FIG. 21—*Recording Wattmeter in single wall case.*

TWIN CASES

All types of instrument cases, with the exception of portables, can be provided to accommodate two standard instruments. Such an arrangement saves switchboard space, and permits the chart drives to be coupled, thus rigidly synchronizing the two records.

	Physical Dimensions			Approx. Weight with Measuring Element and Chart Drive
	Height	Width	Depth	
Twin flush	16"	19"	8¾"*	60 lbs.
Twin switchboard	14"	17½"	9¼"	60 lbs.
Twin Wall	15 3/16"	17⅜"	10⅝"	65 lbs.

*Add 2¾" if instrument has attached multiplier.

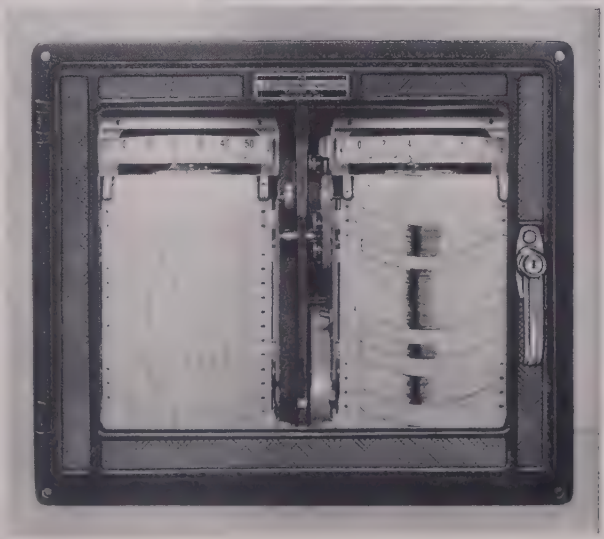


FIG. 22—*Recording Wattmeters in twin flush case.*

For further information ask for Catalog Section 15.

ACCESSORIES AND SUPPLIES

(Catalog Sections 80 and 90)

The usefulness of a graphic instrument is greatly increased through the purchase of accessory and supply items carefully matched to the recorder characteristics. Esterline-Angus instruments are required to operate under a variety of conditions, and the accessories and supplies on the following pages have been developed to have the same adaptability. Their use in combination with Esterline-Angus recorders will assure the greatest possible accuracy and dependability.

FIG. 23—*Portable 7-range Universal current transformer.*

MODEL D UNIVERSAL CURRENT TRANSFORMERS

This metal-clad transformer has primary ratings of 10, 25, 50, 100, 200, 400 and 800 amperes. Four of the ranges are obtained by means of a wound primary, and the other three ranges by looping the conductor through an opening in the core.

Esterline-Angus Universal Current Transformers are designed for use on lines up to 2500 volts, including 4000-volt star circuits with grounded neutral. They have a rating of 25 VA, and are compensated for 15 VA. They are rated for frequencies of 25-125 cycles, and under most conditions are suitable for frequencies up to 500 cycles. The net weight is 24 pounds.

For additional information ask for Model D current transformer bulletin.

SPLIT-CORE CURRENT TRANSFORMERS

Where it is impractical to open a circuit to permit the use of the high-accuracy, closed-core current transformer, split-core transformers are available in several sizes.

Rating in Amperes	Window Opening
25/50/100/200:50MA† *	1 9/16″ x 3½″
150/300/600:5*	1 9/16″ x 3½″
250/500/1000:5*	1 9/16″ x 3½″
500/1000/2000:5*	3¼″ x 4½″
1000/2000/3000:5*	4½″ x 6½″
1500/3000/6000:5	3¼″ x 6½″

*Normally carried in stock. †For use only with rectifier recorders having 0-50MA AC range.

Ratios below 500:5 are intended primarily for use with Esterline-Angus AC ammeters rated 0-5 or 0-5/10 amperes. Errors will not exceed 2%.

Ratios of 500:5 and above when used with Esterline-Angus wattmeters provide accuracy comparable with that obtained from closed core transformers. Phase angle errors may reduce the accuracy with ratios below 500:5 and particularly on circuits where the power factor is low.

For additional information ask for split-core current transformer bulletin.

FIG. 24—*Portable split-core current transformer.*

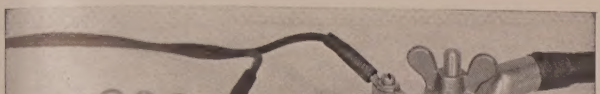


FIG. 25—*Portable ammeter and wattmeter shunt.*

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CHRONOGRAPH PENS (EVENT MARKERS)

In many instances the quantity being recorded is related t
situation or event, and it is desired to key the main record w
Such a record can be obtained by using a chronograph pen. Th
a lateral motion of about 1/10 inch, and record in one or bo
the chart. (See Fig. 5.) The record is similar to that obtained by e
operation recorder. They are actuated by electromagnets con
event being noted.

Chronograph pens can be furnished to operate on any vo
6 and 250. Most ratings consume about 1.3 watts.

FIG. 26—*A Ch*
attachment pro
iary record in th

WRITING DOOR

It is often desirable to make notes on the chart to identify p
record. Frequently, though, recorders are located in places wh
must be kept closed to prevent dirt or corrosive fumes from
mechanism, or must be locked to prevent tampering. For such
a writing door in the glass front of a meter cover can be furn
which notes can be written without opening the cover.

FIG. 27—*A writ*
tates making no

CARRYING OR STORAGE CASES

For convenience in handling, and for protecting the instrument, either during transportation or storage, a carrying case can be provided. The case is made of black fibre, with hinged lid, and is equipped with a carrying handle. It is reinforced with metal corners and clasps, and is lined on the inside to prevent marring the meter case.

Two standard sizes are available. One size is for meters with or without standard attached multipliers and the other size is for meters with external motors or with large multiplier boxes.

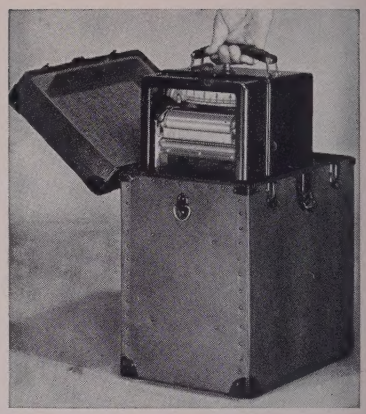
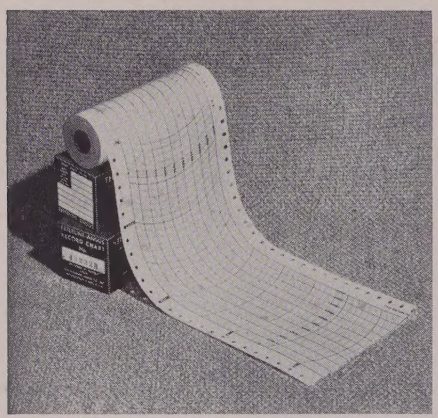


FIG. 29—*Carrying or storage case for portable instruments.*



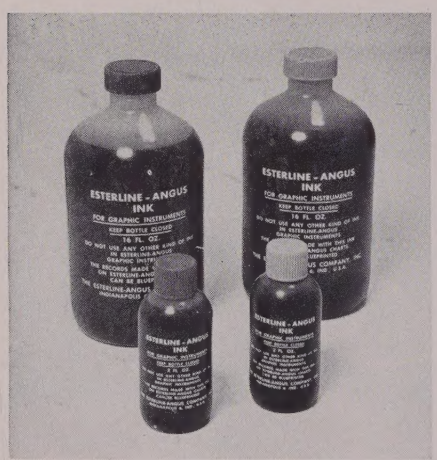
CHARTS

A graphic instrument can be no more accurate than its chart. For that reason, Esterline-Angus charts are made of a special grade of paper, manufactured exclusively for us, having the desired ink absorbing qualities and the minimum change of dimensions with changes of humidity.

All charts are 6 inches wide, the working width being 4½ inches, and 103-feet long. The printing is done in our own plant on special rotary presses designed and built by us.

Over 800 types of charts are in stock at all times and most orders can be filled within one working day after receipt of order. Catalog Section 90 lists all standard chart ranges.

FIG. 30—*All charts are shipped in substantial boxes suitable for filing.*



INK

To few of its products has The Esterline-Angus Company given more study and attention than to the ink supplied for use in graphic instruments. Ink for this purpose has requirements which are quite conflicting. It must not evaporate rapidly in the inkwell, yet it should dry quickly on the chart to prevent blotting. It should have sufficient body to make a clear record, yet it must flow freely and not clog a fine-pointed pen. It must be suitable for use in places where temperatures are quite high, yet must not leave an insoluble residue in the well. Conversely, it must be usable at relatively low temperature.

After years of careful research, we have produced an ink which meets these demands. It is supplied in two colors, red and green and is available in two-ounce or pint polyethylene bottles.

FIG. 31—*Esterline-Angus ink made especially for recording instruments.*

ESTERLINE ANGUS INSTRUMENT COMPANY, INC.

Pioneers in the Manufacture of Graphic Instruments

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Catalog No. 657-B

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